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# ARTS

## TRADITIONAL MUSIC IN THE METAMORPHOSES OF 20TH-CENTURY CULTURE

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### Abstract

This article examines the impact of globalization on 20th-century musical culture. Globalization processes, as is well known, have permeated various spheres of human life throughout the 20th century, exerting a profound influence on society, the economy, political life, and cultural life. These processes have also been prominent in musical culture.

**Keywords:** culture, globalization, ethnicity, tradition, phenomenon, folk song, modification

Musical culture is one of the most mediated spheres of artistic activity today. Music permeates all spheres of human life, creating a unique cultural, linguistic, and informational environment in which sounds and sounds are constantly broadcast on numerous radio stations, television, and various electronic media.

A holistic analysis of contemporary musical culture, in its comparison and its connections with general sociocultural processes, is, in our view, one of the main priorities of cultural studies. The interaction of various musical cultures, the media-driven nature of contemporary culture, the technicalization of music, and the complex interactions of musical texts of diverse origins allow us to conceptualize music as a holistic civilizational system, part of global musical culture.

We understand globalization as the process of forming a unified community and a unified culture across the entire human race, primarily driven by technological revolution (the development of electronic and computer technologies, the growth of mass media, the advancement of global communications, cellular communications, the internet, etc.) and the integration of various spheres of human cultural communication (spiritual, social, and linguistic). By globality, we understand the realities of a global society, a single world, and by globalism, we understand a mode of existence for the modern human community, based on overcoming cultural barriers and boundaries, leading to cultural integration and the emergence of various forms of cultural synthesis.

As is well known, the information and communication trends in the development of modern society are closely linked to the process of globalization.

Many studies analyze new information and communication technologies that played a significant role in 20th-century culture and are growing in importance today (mass media, cable and satellite television, radio, the Internet, computer channels, mobile phone systems, email, digital technologies, video, multimedia, etc.). Scholars devote considerable attention to the modernization of contemporary society and to understanding the informational impact of the new multicultural communication environment (the infosphere) on individuals.

The complexity of the object and subject of this study requires a comprehensive, interdisciplinary approach, drawing on insights from various humanities (philosophy, sociology, psychology, cultural studies, art history, and musicology). In addressing the impact of globalization on 20th-century musical culture, structural analysis methods from the fields of linguistics, computer science, and linguistics are also important, helping to uncover the specifics of musical communication.

Of particular importance to our work is the method of cultural interpretation, essential for analyzing musical texts. In understanding the specifics of musical language and musical thinking in 20th-century culture, as well as the interactions between various types of musical activity (including music education and upbringing), we also employ the methodology of historical and comparative musicological analysis. This analysis is essential for understanding and comparing the characteristics of popular and elite, academic and non-academic, written and oral musical cultures, as well as their interactions with the musical culture of past eras, folklore, jazz, and non-European cultures.

Musical culture of the 20th century is a complex and multifaceted phenomenon that has undergone significant changes and transformations in the era of globalization. Its specificity is manifested in its dynamic development (from the beginning of the century to the turn of the 20th and 21st centuries) based on technological and innovative discoveries, as well as in the complex interaction of traditions and innovations, presupposing a correlation of stable typological features with processuality. The dialectic of tradition and innovation in 20th-century musical culture is realized through the active growth of innovative components based on the combination of technical means and elements of media culture with creativity, leading to a gradual renewal of musical thinking, the composition of the sound environment, and the specifics of musical activity.

The most significant typological features defining the novelty of 20th-century musical culture are the dichotomy of a number of phenomena, foremost among them the opposition between mass and elite musical culture. In no previous era had this opposition been so global in its scope and significance for the development of musical culture as a whole. In the 20th century, and particularly at the turn of the 20th and 21st centuries,

this opposition became decisive in shaping worldviews, the norms and rules of creativity, and the evaluative criteria for musical art. At the same time, the sphere of academic music finds itself on the periphery of culture, especially in the present era, when the prestige of the composer's profession is noticeably declining, listener interest in classical music is significantly declining, and so on. The so-called "third layer" (all everyday culture, according to V. Konen) occupies a leading position, actively merging with media culture. Moreover, the sphere of mass music, with its pronounced focus on the spectacular and entertaining component, commercial success, and technical innovations, also involves academic musical art in its "consumption" space.

Along with the dichotomy of mass and elite culture typical of 20th-century musical culture, other dichotomies also appear important: oral and written, auditory and visual. Their interaction leads to an expansion of music's intonational field, the emergence, as noted, of "mixed" forms, which attests to the formation of new types of musical thinking in the era of globalization: rational-pragmatic and integrative. As noted in the work, the traditions of the classical-romantic era are being replaced by new principles of composition, combining technical electronic means and creativity. In 20th-century compositional practice, this is manifested in the strengthening of analyticism and constructivism in the techniques of musical composition themselves, a change in the acoustic genesis and intonational-sound composition of the musical environment influencing creativity. The opposition between oral and written (musical) cultures also appears in a different relationship, manifested in the increasing role of improvisational practices with their reliance on non-written forms of creativity.

In the context of globalization, the sphere of listening culture is also undergoing significant transformations; depending on the mass media, the specifics of listening perception are modified, a new media-saturated type of public is formed, focused mainly on the consumption of mass culture products, the ratio of collective and individual forms of listening to music is changing, a significant gap often arises between the level of professional composition and performance and the capabilities of listening perception of those segments of the public that are mainly addressed to average stereotypes and standards of mass production (in the interests of commerce and business), which can be seen as features of a crisis.

All the noted features of the musical culture of the 20th century allow us to draw a general conclusion about the formation of a new cultural paradigm of a modernized integration type in the era of globalization (Найдорф М.)

To fully understand the globalization of music, it is crucial to review its historical evolution. This process is not a recent phenomenon. It finds its roots in the cultural and commercial exchanges that have shaped societies for centuries. Since the colonial era, interactions between different cultures have influenced music, with examples of musical from this time. However, it was

with the advent of economic and technological globalization in the 20th century that the globalization of music experienced unprecedented expansion.

Innovation such as audio recording, radio, television, and more recently the internet and streaming platforms have therefore radically transformed the diffusion and reception of music on a global scale (<https://onetribe-studio.com/en/globalization-of-music-impact-on-cultural-diversity>).

Globalization has transformed the way we interact with music, breaking down barriers and fostering cross-cultural exchanges. Today, people can easily access music from any part of the world, whether through streaming platforms or viral hits. This unprecedented interconnectedness has not only enriched our playlists but also redefined how music is created, distributed, and appreciated. Let's explore how globalization has influenced the music industry and what it means for artists and listeners alike. (<https://vocal.media/fyi/the-impact-of-globalization-on-music>).

Reflecting on globalization as a current sociocultural phenomenon, one inevitably encounters the following questions: What is the essence of the term "globalization" and what is its role in recent literary processes? These issues are so complex that they undoubtedly require a specialized, even delicate, approach.

First of all, it should be noted that the concept of globalization itself is not directly related to literature and literary criticism, and therefore the tradition of using the term in this field is virtually nonexistent. Although the concept of "global" in its traditional meanings ("all-encompassing," "universal," "worldwide") is far from new, its widespread adoption dates back to the 1960s, primarily in economic and sociological publications and the media. Gradually but surely, the term is also entering the lexicon of academic circles.

Today, in the era of communication, cultural unification is expanding beyond the national sphere to the global level. As a result of modernization, "exchanges" for the exchange of ideas have already emerged in all fields. We attend these "exchanges" not as individuals, but as representatives of our societies.

Essentially, this is the process of transforming literature into an endless stream of jumbled words and expressions, in which traditional signs and purposes have no priority, and literature itself completely loses its representative function. This is demonstrated by the endless textuality that surrounds us in the form of scientific and journalistic reports, political news, daily stories, and signs. Thus, every text becomes literary, and in this process of piling up literary traces in everything related to words and text, literature loses not only its distinctness but also its distinctiveness. The entire field of textuality, freed from mimetic illusion and imagination in general, acquires the significance of a new literariness.

It's pointless to expect this kind of literature to depict real existence, individual societies, and social change. This new type of literature cannot tolerate the realistic depiction and social conditioning that were emphasized in the past. Under conditions of globalization, literature reveals the meaning of social processes,

surrendering to the stock exchange and the market, where a specific logic operates. In this brutal process, the illusion of the importance of cultural diversity is erased. Everything is reduced to market demands, mass entertainment, and profit. Now literature is viewed as any other commodity on the exchange of ideas, information, and knowledge, which are directly converted into money. The previously privileged position of literature as society's darling no longer exists. Even ideological pressure and control over literature are gone. The social dictate familiar from the previous era is also disappearing—but at the same time, so is literature's significance in public life. Its only function is to entertain and provide pleasure. It takes on popular forms that are deliberately controlled by the institutions of globalization (the stock exchange and the media). It doesn't matter that the excessive development of new pop culture traumatizes the individual's psyche and destroys their thinking abilities. At the same time, serious books and ideas cease to be socially significant.

Music and globalization are closely linked: music serves as a tool for cultural exchange, transcending borders thanks to technology and the internet, and facilitating both the unification and fusion of cultures. Globalization leads to the emergence of new, hybrid musical forms, the expansion of sound boundaries through electronic instruments, and the spread of musical genres across the globe.

It's important to understand that the globalization of music isn't just about hearing any composition anywhere in the world. It also involves the influence of certain styles on others, the blending of genres, and the birth of new forms. Jazz originated in the United States but became the foundation for European improvised music. African folk music inspired an entire generation of Western musicians. Russian classical music influenced the opera tradition in Japan. Contemporary hip-hop brings together voices from Los Angeles, Paris, Seoul, and New York. The examples are endless.

However, globalization brings not only the joy of discovery but also questions. What is happening to local traditions? Are they disappearing under the pressure of popular culture? Are we losing our uniqueness when we try to speak a single language? These questions are being asked by ethnomusicologists, educators, and representatives of folk cultures. They see how young people are increasingly choosing what's "in" and forgetting their roots.

But there's another side to this: globalization offers the opportunity to preserve these very traditions, making them known to the world. Ancient songs that might otherwise have been lost to history are now finding new life thanks to international interest, modern productions, and online platforms.

Interestingly, the globalization of music influences not only listener choice but also the creative environment itself. Musicians are beginning to collaborate, despite distance. Artists from different countries are creating joint tracks, releasing videos, and writing lyrics in several languages. This is no longer just a collaboration—it's a new stage in the development of music, where style, language, timbre, and rhythm can change within a single composition. This is how new

directions are born that cannot be classified by the old rules.

Furthermore, globalization is changing the perception of music. People have become more open to different sounds, different approaches, and different emotions. We're no longer surprised when an artist with an instrument from South America performs at one festival, followed by an electronic DJ from Europe. We accept this as the norm, as a given. Yet just recently, such a combination seemed impossible.

Commercialization, standardization, and loss of originality are all linked to globalization. Sometimes it seems like everything is becoming monotonous, like music videos, tracks, and images are repeating themselves. But this is more a question of consumption than the music itself. After all, beyond the popular charts, hundreds of thousands of projects continue to exist that don't strive for mass production, but remain true to their culture, their language, their soul.

Ultimately, the globalization of music isn't just a phenomenon outside of us. It's part of our lives, our perceptions, our preferences. It's inevitable, because music has always been a universally understood language. It's just that now this language speaks all languages at once, without borders or translation. And if we want to preserve this wealth, it's important not just to consume music, but also to **hear** it, **feel** it, **respect** it, and **preserve** the sincerity that makes music alive and real.

Musical globalization also impacts education. Music classes in schools and universities have become broader: instead of narrowly nationalized programs, students study music from all over the world. Technology makes it possible to master instruments previously unknown to only a few. This opens up new horizons, but also poses new challenges for teachers: how to teach not just technique, but also respect for diversity, and how to maintain a sense of proportion between the global and the local.

Another important aspect is accessibility. Previously, to hear music from another country, you had to buy a record, wait for it to be released in your city, or see a live performance. Today, all you need to do is turn on a streaming service, and the whole world opens up to you. This incredible freedom of choice influences the development of taste, the formation of personality, and the understanding of cultural differences.

Now it's becoming part of a digital space where there are no borders, and cultural barriers are becoming thinner every day. What was once considered exotic is now featured on every other playlist. And this is no coincidence - it's a consequence of global cultural exchange, in which music plays a role as one of the most powerful tools of interaction.

A computer, combined with these devices and programs, simplifies music creation. They offer incredible music-processing capabilities, allowing you to add accompaniment in various styles to a melody, and automatically create arrangements of virtually any complexity. A computer can even compose music according to predefined rules.

Globalization processes, as evident from the above definitions, have cultural significance, as they encompass the entire sphere of human activity. This has been noted by many Western and Russian philosophers and cultural scholars studying globalization issues. They, in particular, point out that globalization processes are based on objective laws of human and social development. They are based on civilizational processes of integration, as well as the formation of media culture associated with industrialization, the development of mass communications, and information media. A distinctive feature of the formation of modern media culture is the global expansion of the information environment, the foundation of which is the intensive communicative interaction of various information environments.

The processes of globalization in 20th-century musical culture and the powerful information and technological advances in the development of music have led to significant changes in the mechanisms of musical cognition in all its manifestations. This process is characteristic of various spheres of human spiritual activity in the 20th century, including the arts.

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# BIOLOGICAL SCIENCES

## PHYLOGENETIC ANALYSIS OF NODULE BACTERIA *ESPARSETA ONOBRYCHIS* SP., USING 16S rDNA

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### Abstract

Rhizobia were isolated from the root nodules of perennial plant *Esparseta Onobrychis* sp., from Desert of Central Asia. The phylogeny of the isolates was investigated using 16S rDNA. The phylogenetic tree of the 16S rDNA showed that many of the isolates belonged to *Rhizobium* sp., *Sinorhizobium* sp., *Pantoea agglomerans*, and to *Paenibacillus polymyxa* strain. The acetylene reduction activity was higher for the many isolates inoculated with host plants in micro vegetation experiments. The plasmid profile showed to the *Rhizobial* isolates has some many big plasmids, analogical to *Sinorhizobium meliloti* 41AK631. When the plant was re-inoculated with new nodule bacteria, a high activity of reducing acetylene per plant was observed, and the effective plant growth was higher of the first once. Based on these data, we assume that an effective rhizobia inoculant has been identified for the plant *Esparseta Onobrychis* sp.

**Keywords:** Nitrogen fixation; 16S rDNA: plant *Esparseta Onobrychis* sp., *Sym plasmids*

**INTRODUCTION.** The perennial plant *Esparseta Onobrychis* sp., belonging to the legume family, is characterized by a powerful development of the root system. Their shoots are 75-100 cm high and above. In Central Asia, they are distributed mainly in desert and arid zones. Due to their ability to form nodules on the roots and high nitrogen-fixing ability, they are less demanding of moisture than other legumes; they are valuable forage plants, rich in protein and other nutrients, resistant to high drought resistance and sufficient winter hardiness [1].

Bacteria of the genus *Esparseta Onobrychis* sp., with wide host specificity, are found in the Arctic and subarctic regions. Prevost and all showed that in legumes growing in the northern regions, these bacteria enter into symbiosis and form nodules, and nodule-forming genes (Nods) were characterized as the first step towards changing the specificity of the nodule host [3].

The genetic diversity of rhizobium isolates isolated from wild legume species *Esparseta Onobrychis* sp., originating from different geographical locations, was evaluated using the analysis of 16S rRNA gene polymorphism at the restriction site (MRSP) and PCR DNA fingerprinting with repeated sequences (REP-PCR) [4]. From the REP-PCR data, the authors identified only three examples in which rhizobia of the same plant species appeared to be closely related (two strains of *Astragalus sinicus*, Two strains of *Onobrychis vicifolia*, and three strains of *Astragalus cicer*. These results are consistent with previous classifications in other publications on serology, numerical taxonomy, and cross-infection experiments involving rhizobia from *Astragalus*, *Oxytropis*, and *Onobrychis* spp. They were grouped regardless of their plant origin [4].

The aim of the work was to study the genetic diversity and phylogeny of nodule bacteria of wild legume species from the arid zones of Central Asia and to develop approaches to using the biological potential of these bacteria.

### MATERIALS AND METHODS

Pink nodules were collected from the root of a plant species *Esparseta Onobrychis*. The nodules were sterilized in ethyl alcohol at 96°C for 5 minutes. Then it was washed several times with bi-distilled water, and placed in an Eppendorf tube and blown with a sterile glass wand until a homogeneous mass was obtained, bi-distilled water containing 10% sucrose was added, the liquid part was diluted several times and grown on a solid agarized dish with a medium for nodule bacteria, as described in the article [5]. Bacterial colonies appeared within three days. Bacteriologically pure nodule bacteria were isolated from single grown colonies.

**Microvegetation experiments.** For microvegetation experiments *Esparseta Onobrychis* sp., seeds were treated by concentrated sulphuric acid during 6-7 minutes, then after their numerous washing by sterile water the treated seeds were put on sterile Petri dishes and were incubated in thermostat at 30°C temperature for 1-2 days. After before their germination, were collected the same size (length of seedlings). The germinated seeds further were introduced into tubes with volume 60 ml with sterile vermiculite (3:1), height of which was 8 cm, containing nutritive medium for plants, as writed in S. Fedorov et all, [6].

**Determination of nitrogen-fixing activit.** Nitrogen-fixing activity was assessed using the acetylene reductase activity (APA) assay described by Hardy [7]. Plant samples (with root nodules) were washed with sterile water and placed in agronomic tubes with a capacity of 60 ml, equipped with sealed rubber stoppers. Acetylene (10% by volume) was injected and the tubes were incubated at 30°C for 24 hours. The data obtained was average for three repetitions. Acetylene-free samples were used as a control. The quantitative assessment of ethylene gas formed in the samples was carried out on a gas chromatograph (LHM-80). Acetylene reeducates activity in plants was expressed in nmols of C<sub>2</sub>H<sub>4</sub> per tube per hour.



**CTAB is the extraction of genomic DNA.** Bacterial nodule cells were grown to a logarithmic phase, and genomic DNA was isolated from these cells, as indicated in Professor Sharon Long's laboratory protocol manual. With some modifications [8], as well as according to the method of Dr. J.Marmura [8].

**PCR amplification of the 16S rRNA gene.** The 16S rDNA genes from nodule bacteria were amplified using universal primers 1070f (59-ACGGGCGGTGTGTAC-39) and 1392r (59-CGCCCCGCCGCGCCCCGCGCCCCCGCCCCCGCCCCGCGGTGTGTAC-39), as described in M.J.Ferris et al., 1996 [9].

**Phylogenetic analysis.** The complete sequences of 16S rDNA genes with a length of 300-354 bp were compared with the sequences available in the GenBank database using the standard BLASTn basic local alignment search tool [10] at the National Center for Biotechnology Information (NCBI) (<http://blast.ncbi.nlm.nih.gov/Blast.cgi>). Dendrograms connecting neighbors were constructed from aligned sequences [11] using the MEGA software version 4.0.2 [12]. The reliability of the obtained trees was evaluated using 1000 repeated bootstrap samples.

**RESULTS.** The nodules were collected from plants that had grown to one meter and placed in an agar medium to maintain humidity. The isolation of bacteria is described in the section materials and methods. Microscopic studies of some bacterial cells of the selected strains showed that the studied cells were represented by typical movable rods. The growth rate of the isolated nodule bacteria strains depends on the cultivation conditions and is one of the most important taxonomic features. At the same time, a well-formed colony of fast-

growing bacteria can be obtained after 3-4 days of growth, and for slow-growing ones - after 7-10 days. In a medium containing agar-agar, isolates of nodule bacteria formed colorless, transparent, mucous colonies. This type of colony of isolates was typical for S-forms of bacteria

We have tested the resistance of these bacteria to antibiotics. The table shows the data.

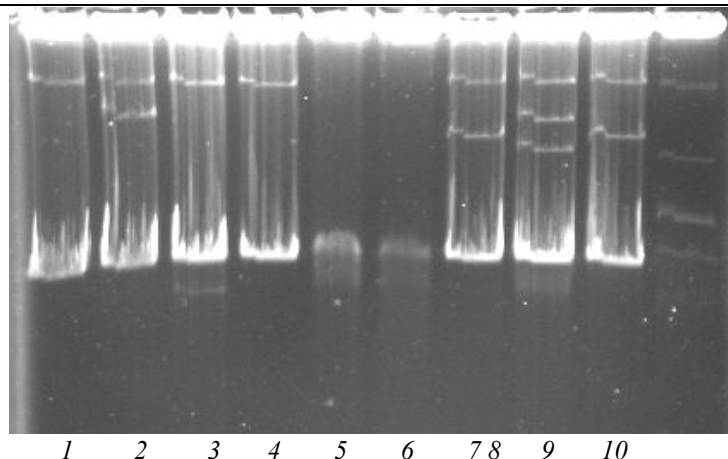
There were used Ampicillin (100 µg/ml), Vancomycin (100 µg/ml), Rifampicin (100 µg/ml), Neomycin (50, 100 µg/ml), Kanamycin (100 µg/ml), Streptomycin (100, 200 µg/ml), Chloramphenicol (50, 100 µg/ml), which had been added into agarized TY medium. The bacterial growth on these antibiotic-containing TY medium was checked during 3 days at 30°C in thermostat.

For all types of rhizobia, a high level of strain diversity is observed in natural populations, in particular, in the composition of plasmids. The genes responsible for the formation of an effective symbiosis with a legume plant are localized in rhizobia mainly on a high-molecular (up to 1000 microns) "symbiotic" plasmid. In addition to Sym, plasmids in bacterial cells contain up to nine plasmids of different molecular weights (400, 500 and 600 microns), which are called cryptic. However, the functional role of these plasmids is unclear. For some strains of rhizobia, it has been shown that the presence of cryptic plasmids can affect the viability of bacteria or determine their adaptive abilities (Rastogi V. K. et al., 1992; Djordjevic et al., 1982). [13, 14]. However, the survival of strains in the soil often depends on their resistance to stress factors (temperature, salt tolerance, etc.). In addition, the role of host plants as the main ecological selective factor affecting the number and structure of populations of soil rhizobia is widely discussed.

Table.1.

Antibiotic resistance isolates *Rhizobium Onobrychis transcaucasica*

|              | <i>Amp</i><br>100 | <i>Van</i><br>100 | <i>Rif</i><br>100 | <i>Nm</i><br>50 | <i>Nm</i><br>100 | <i>Km</i><br>25 | <i>Km</i><br>100 | <i>Str</i><br>100 | <i>Str</i><br>200 | <i>Cm</i><br>30 | <i>Cm</i><br>50 | <i>Cm</i><br>100 |
|--------------|-------------------|-------------------|-------------------|-----------------|------------------|-----------------|------------------|-------------------|-------------------|-----------------|-----------------|------------------|
| <i>T-102</i> | +                 | +                 | +                 |                 | -                | +               | -                |                   |                   | +               | +               |                  |
| <i>T-103</i> | +                 | +                 | +                 |                 | -                |                 | -                |                   |                   | +               | +               | +                |
| <i>T-111</i> | +                 | +                 | +                 |                 | -                | +               | -                | +                 | +                 | +               | +               |                  |
| <i>T-115</i> | +                 | +                 | +                 | +               | -                | +               | -                | +                 | +                 | +               | +               |                  |
| <i>T-117</i> | +                 | +                 | +                 | +               | -                |                 | -                |                   |                   | +               | +               |                  |
| <i>T-118</i> | +                 | +                 | +                 |                 | -                |                 | -                |                   |                   | +               | +               |                  |
| <i>T-121</i> | -                 | +                 | +                 | +               | -                | +               | -                | +                 |                   | +               | +               |                  |
| <i>T-122</i> | +                 | +                 | +                 |                 | -                |                 | -                | +                 |                   | +               | +               |                  |
| <i>T-123</i> | +                 | +                 | +                 | +               | -                |                 | -                |                   |                   | +               | +               |                  |
| <i>T-130</i> | +                 | +                 | +                 |                 | -                |                 | -                | +                 | +                 | +               | +               |                  |
| <i>T-136</i> | +                 | +                 | +                 |                 | -                |                 | -                | +                 | +                 | +               | +               |                  |
| <i>T-139</i> | +                 | +                 | +                 |                 | -                |                 | -                | +                 |                   | +               | +               |                  |
| <i>T-140</i> | +                 | +                 | +                 | +               | -                | +               | -                | +                 | +                 | +               | +               |                  |
| <i>CH-7</i>  | +                 | +                 | +                 | +               | -                |                 | -                | +                 | +                 | +               | +               |                  |



Pic. 2, Eckhardt-type gel electrophoresis showing plasmid profiles of isolated bacteria that had the Sym plasmids.

Lanes: 1-4, 7-9 *Rhizobium Onobrychis* sp., lines 5-6 *Paenibacillus polymyxa*., line 10 *Sinorhizobium meliloti* 41AK631. The bands corresponding to plasmids *Rhizobium*

The plasmid profile has executed according to Eckhardt's method revealed that we did not find plasmids in the genome of *Paenibacillus polymyxa*. line 4-5, Compared to the control line 10. (plasmid *Sinorhizobium meliloti* 41AK631). In line 1,2,3,4, and 7,8,9 where were *Rhizobium Onobrychis* were high molecular plasmids with size 1800 bp. This results indicates that the main symbiotic nitrogen fixation genes are integrated in these Sym plasmids [15].

#### Microvegetation and vegetation experiments.

The seeds for experiments on growing microvegetations were treated with concentrated sulfuric acid for 5 minutes, followed by repeated rinsing with sterile water. The treated seeds were placed in sterile Petri dishes containing 1% agar and incubated in a thermostat at 30°C for 1-2 days. The germinated seeds were placed in glass tubes with a volume of 60 ml, and 8 ml of this medium were added. as written in the Materials and methods section, Fedorov S.N. et al., 1983. [6]. The plants were inoculated with a bacterial suspension in the amount of  $10^9$  cells/ml and grown in sterile greenhouse conditions for 45 days. Each vaccination option has 10 repetitions of 1 plan in one repeat. The nitrogen-fixing activity of nodule bacteria was determined by the activity of acetylene reductase on an LHM chromatograph. These data for *Onobrychis transcaucasica* plants ranged from 28 to 63 nmol  $C_2H_4$ /hour/tube, and for *Onobrychis chorassanica* from 29 to 51 nmol  $C_2H_4$ /hour/tube [7].

**CTAB genomic DNA extraction.** We used the method Dr. J.Marmur with some modification. This method has been described for the isolation of DNA from micro-organisms. The isolated DNA from micro-organisms is biologically active, highly polymerized preparations relatively free from protein and RNA. The modifications methods of cell disruption and DNA isolation have been described and compared with isolated DNA from other cultures microorganisms.

**PCR amplification of the 16S rDNA gene.** For the amplification 16s rDNA region genome we used several universal primers which used from many scientists to amplify the 16s rRNA region of the genome, but none of these primers could synthesize the ribosomal

region, only those primers used by Dr. M.J.Ferris were fully amplified 16s rRNA region of the genome. The nucleotide sequence of this site was determined from the databank NCBI that these bacteria belong to nitrogen-fixing bacteria, and in addition to it, they are very close relatives. The 16S rRNA gene from nodule bacteria of *Onobrychis transcaucasica* and *Onobrychis chorassanica* was amplified using universal primers 1070f and 1392r as written in the article M.J.Ferris et al., 1996 [9].

**Phylogenetic analysis of the 16S rRNA gene of nodule bacteria strains.** The taxonomy of bacterial isolates isolated from the nodules of *Onobrychis transcaucasica* and *Onobrychis chorassanica* plants was studied using the 16S rDNA gene method. The nucleotide sequence of the 16S rDNA gene of the site made it possible to identify the specific affiliation of bacteria to the genus, and for some bacteria, down to the species. The results of a comparative BLAST analysis of the nucleotide sequence of the conserved region of the 16S rRNA gene of bacteria 4-isolates from *Onobrychis transcaucasica* were 99% identical to the genes of *Rhizobium etli* strain SEMIA 284 16S ([AY904730.1](#)) Interestingly, the nucleotide sequences of bacteria 9-isolates from *Onobrychis transcaucasica* also have 96-98% identity with the genes of *Sinorhizobium meliloti* CCNWYC140 ([EU849576.1](#)), *Sinorhizobium meliloti* ([AB535707.1](#)), *Sinorhizobium fredii* CCBAU 10078 ([GU552900.1](#)), *Mesorhizobium mediterraneum* Zw-2-1 ([GU201845.1](#)), *Mesorhizobium obense* Zw-1 ([GU201844.1](#)), *Bradyrhizobium japonicum* PRY65 ([AF239848.2](#)) bacteria. The conservative region of 16S rRNA gene of OT114, OT124, OT148 bacteria coincides by 98-99% with genes of *Pantoea agglomerans* GS2 ([GQ374474.1](#)), *Enterobacter cloacae* IHB B 1374 ([GU186117.1](#)) and *Pantoea agglomerans* MKPTK-4 bacteria ([GQ499274.1](#)) accordingly, and *Paenibacillus polymyxa* strain GBR-477 ([AY359625.1](#)) and ([AY359620.1](#)), respectively.

Similar results were obtained for nodule bacteria from *Onobrychis chorassanica*. Analysis of the 16S rRNA genes of the nodule bacterium *Onobrychis cho-*

*rassanica* showed that the nucleotide sequence of bacteria OC104, OC107, OC109, and OC111 coincides by 98-99% with the genes of *Rhizobium etli* strain SEMIA 284 16S (AY904730.1)

Moreover, 16S rRNA genes of OC104, OC107, OC109 bacteria by 97-99% were homologous with genes of several bacteria species such as *Sinorhizobium meliloti* CCNWX C140 (EU849576.1), *Sinorhizobium meliloti* YcS2 (AB535707.1), *Sinorhizobium fredii* CCBAU 10078 (GU552900.1), *Mesorhizobium tianshanense* (FM203306.1), *Mesorhizobium amorphae* CCNWYC131 (EU849577.1) and *Bradyrhizobium japonicum* PRY62 bacteria (AF239847.2). The bacterium OC112 is 99% identical by with nucleotide sequences of 16S rRNA gene of *Burkholderia caryophylli* WAB1944 (AM184283.1), the genes of OC106 coincides by 97% with genes of *Pantoea agglomerans*

HXJ (HM016799.1), genes of OC138 by 98% coincides with genes of *Enterobacter* sp. RF-100 (GQ205104.1) and genes of OC113 bacteria by 97% are identical with genes of *Enterobacter* sp. B-13M3 (AJ874743.1).

When studying the phylogenetic tree based on the nucleotide sequences of 16S RNA, various bacteria were found that studied 9 isolates of *Onobrychis transcaucasica* belonging to the class of alpha-proteobacteria (Figure 4a), but the bacteria OT114, OT124, OT148 were classified as gammaproteobacteria. The phylogenetically ancient nodule bacterium *Onobrychis choras-sanica*, unlike the bacterium *Onobrychis transcaucasica*, has three clusters. The bacteria included in the 1st cluster were alpha-proteobacteria, the 2nd cluster was beta-proteobacteria, the bacteria of the 3rd cluster belonged to the class of gammaproteobacteria, in particular to the genera *Enterobacter* and *Pantoea* (Fig.4)

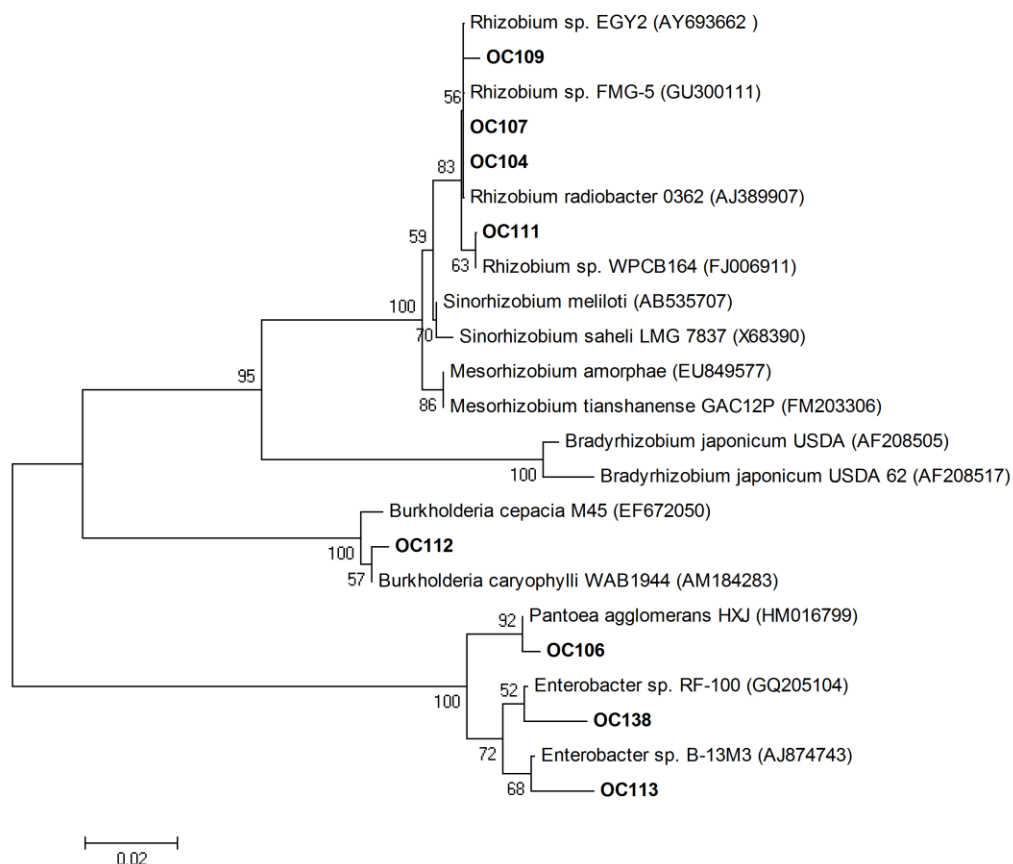


Figure 4. Phylogenetic tree based on the 16S rDNA gene strains of nodule bacteria *Onobrychis chorassanica*: a- Alphaproteobacteria; b- Betaproteobacteria; c- Gammaproteobacteria. The branching pattern was produced by the neighbour-joining method. The GenBank accession numbers for the sequences used are indicated in parentheses. Symbionts of *Onobrychis chorassanica* are shown in bold type.

**DISCUSSION.** The success of the process of nodulation and nitrogen fixation depends on the successful survival ability, competitiveness, and efficiency of the rhizobial strains involved. Redmond et al. 1986; Lerouge et al. 1990; Polonenko et al. 1993; Prevost et al. 2003, in scientific investigations has been shown in within the soil, various factors like type and variety of host and bacterial strains, soil physical and chemical properties, temperature, light, plays and important role

in interaction with other rhizospheric microorganisms [18, 19, 20, 21]. One way to achieve successful symbiosis and nitrogen fixation is to provide optimum conditions to rhizobia inoculants which are not possible under field conditions.

It was previously shown that edaphic factors and prevailing environmental conditions determine the distribution of the rhizobia population. For example, soil pH and P, temperature, salinity and moisture content

strongly influence the diversity of rhizobia strains in various agro ecological regions [22, 23, and 24].

However, the sufficiency of the symbiosis to meet plant N requirements was not reported. Prevost D, Bordeleau L.M and Antoun H, (1987a), Prevost, Bordeleau, Caudry-Reznick, Schulman, and Antoun (1987b), Prévost et al. (2003) showed enhanced growth of arctic rhizobium at  $<5^{\circ}\text{C}$ , as well as effective nodulation in sainfoin. [25, 26, 27, 28].

D.K.Jain, D.Prévost, L.M.Bordeleau. (1990) also used arctic rhizobium along with mutagenesis and documented improved  $\text{N}_2$  fixation with selected strains, indicative that optimization of the inoculant for sainfoin is possible and deserves further attention [29].

Laguerre et al. 1997; Prevost and Bromfield 2001; Prevost et al. 2003, in own scientific works have written that the bacteroids observed within the *Astragalus* nodules were clearly expressing the nifH protein of nitrogenase, thus reinforcing the strong likelihood that the plants were fixing  $\text{N}_2$  at the time that they were harvested [4]. Although the exact nature of the *Astragalus* symbionts is so far unknown, cold-adapted *Mesorhizobium* strains were the principal symbionts isolated from *A. arcticus* and from species of the closely related genus *Oxytropis* in Canada [30].

## Conclusions

In conclusion of our discussion, those nodule bacteria in associations enter into nitrogen-fixing symbiosis with plant hosts. Based on the data obtained, in the discussion we showed several scientific works of scientists who studied the nitrogen fixation properties of nodule bacteria in cold conditions. In the Arid zones there are many stress factors, such as water stress, temperature, pH and others, and in these conditions, the struggle for the survival of microorganisms occurs due to their activity. Microorganisms are attached not only to root plants, but also to nodule of plants themselves.

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**TAXONOMIC ANALYSIS OF 16S rDNA OF SOYBEAN NODULE BACTERIA  
(GLYCINE MAX (L.) MERR.)**

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**ТАКСОНОМИЧЕСКИЙ АНАЛИЗ 16S рДНК КЛУБЕНЬКОВЫХ БАКТЕРИЙ СОИ (GLYCINE  
MAX (L.) MERR.)**

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**Abstract**

A total of 20 strains of nodule bacteria were isolated from soybean plants (*Glycine max* (L.) merr.). The study of bacterial nodules in these plants in a microvegetation experiment yielded a very low level of nodules on the roots of the plants. In a vegetation experiment, intensive nodulation of soybean plants was noted. The cultural and morphological properties of the bacteria showed that they formed colorless mucous colonies, were gram-negative and had rod-shaped cells. When viewed under a microscope, their high mobility was noted. Nucleotide sequencing of the 16S rRNA gene and BLAST analysis showed that the isolated fast-growing and slow-growing soybean nodule bacteria belong to the genera *Bradyrhizobium japonicum* and *Sinorhizobium fredii*.

**Аннотация**

Всего из растений сои (*Glycine max* (L.) merr.) выделено 20 штаммов клубеньковых бактерий. Исследование клубеньков бактерий в этих растениях в эксперименте по микровегетационному опыту дало очень низкий уровень клубеньков на корнях растений. В вегетационном эксперименте отмечена интенсивная клубеньков на корнях растений сои. Культурально-морфологических свойств бактерий показало, что они образовывали бесцветные слизистые колонии, были грамотрицательные и имели палочковидную форму клеток. При просмотре под микроскопом отмечали их высокую подвижность. Нуклеотидное секвенирование гена 16S рРНК и анализ BLAST показали, что выделенные быстрорастущие и медленно растущие клубеньковые бактерии растений сои относятся к родам *Bradyrhizobium japonicum* и *Sinorhizobium fredii*.

**Keywords:** root nodule bacteria (rhizobia), symbiotic N<sub>2</sub>-fixation, 16s rDNA.

**Ключевые слова:** клубеньковые бактерии, симбиотическая N<sub>2</sub>-фиксация, 16s рДНК.

Симбиоз бобовых растений с клубеньковыми бактериями - одна из наиболее эффективных систем биологической азотфиксации, имеющая огромное экологическое и практическое значение, и, кроме того, растительно-микробные взаимоотношения служат прекрасными моделями для выяснения ряда фундаментальных и прикладных вопросов биологии [1]. Они объединены тесными экологическими связями, но в них не происходит обмен генетическим материалом. Использование филогенетических, популяционно-генетических и молекулярных подходов позволяет изучать симбиоз как продукт коэволюции партнеров, которая представляет собой совокупность макро- и микроэволюционных процессов, осуществляемых в генетически интегрированных биосистемах [2]. Однако при изучении совместного влияния друг на друга природных симбиотических систем, представленных бобовыми растениями и бактериальными клетками (ризобиями), как правило, пристальное внимание уделяется одному из партнеров.

Целью и задачи исследования входили, выделить местные клубеньковые бактерии рода *Bradyrhizobium japonicum* и *Sinorhizobium fredii* образованные на корнях растений сои, произрастающих в

почвах Ташкентской области, изучить бобово-ризобиальный симбиоз и их влияние на рост-развития и урожайность бобовых растений, изучить их систематического положения путем анализа 16S рРНК гена и плазмидного состава.

**Материалы и методы.** Выделение ризобий из клубеньков растений-хозяев проводили по стандартной методике. Клубенек стерилизовали в 96 %-м спирте, промывали, затем растирали в небольшом количестве воды. Полученную суспензию высевали на агаризованную питательную среду ТУ. Для получения однородной культуры штаммов ризобиальных клеток проводили 2-кратные пересевы колоний [3]. Для повторного выделения клубеньковых бактерий использовалась методика инокулирования растений-хозяев с *Bradyrhizobium japonicum* и *Sinorhizobium fredii* в стерильных микровегетационных опытах с последующим выделением ризобий из образовавшихся клубеньков [4].

**Работа с ДНК.** Экстракцию бактериальной ДНК проводили по следующей методике. Ночную культуру ризобиальных клеток выращивали в жидкой среде ТУ при 28 °C [5]. Через 6 суток медленно растущие бактерии *Bradyrhizobium japonicum*, а быстрорастущих ризобий *Sinorhizobium fredii* после 30 часов осаждали центрифугированием, затем



осадкам добавляли лизирующий раствор (TRIS-HCl, pH 8,0, 25 mM, EDTA 10 mM, РНК-аза 0,2 мг/мл, лизоцим 1 мг/мл), инкубировали 5 мин при комнатной температуре, а затем добавляли 10 %-й (w/v) раствор SDS до конечной концентрации 1 % (w/v). Лизаты инкубировали при температуре 65 °C 30 мин, к лизатам добавляли 1/10 объема 3 М ацетата натрия и осаждали двумя объемами этилового спирта. Далее проводили очистку ДНК от белковых примесей методом фенол-хлороформной экстракции, после которой ДНК осаждали этиловым спиртом. Для определения таксономической принадлежности использовали метод 16S рРНК. Для амплификации 16S рРНК участка использовали праймеры 1070f (59-ACGGGCGGTG TGTAC-39) и 1392r (59CGCCCGCCGCGCCCCGCGCCCGGCCCCGCCGCCCCGCCCCACGGGCGGTGTGTAC-39) [6, 7].

Далее полученные ДНК-фрагменты были секвенированы и анализированы в программе NCBI.

## Результаты исследования и их обсуждение.

Выделение ризобий проводили из клубеньков на корнях сои, собранных на полях Ташкентской области. Для выделения ризобий были отобраны здоровые и мощные растения с хорошо развитой корневой системой и большим числом клубеньков на корнях. В общей сложности было собрано 30 растений сои. В лабораторных условиях из клубеньков на корнях сои было проведено выделение ризобий на питательной агаризованной среде МРС, следующего состава г /л: NaCl – 0,2; соль Мо – следы; маннит или лактоза – 20,0; соевая мука – 10,0; агар – 20,0. Засеянные чашки Петри инкубировали в термостате при 30°C. Быстрорастущие ризобии появлялись на 2–3–4, медленнорастущие – на 7–9–10 сутки (рис. 1).

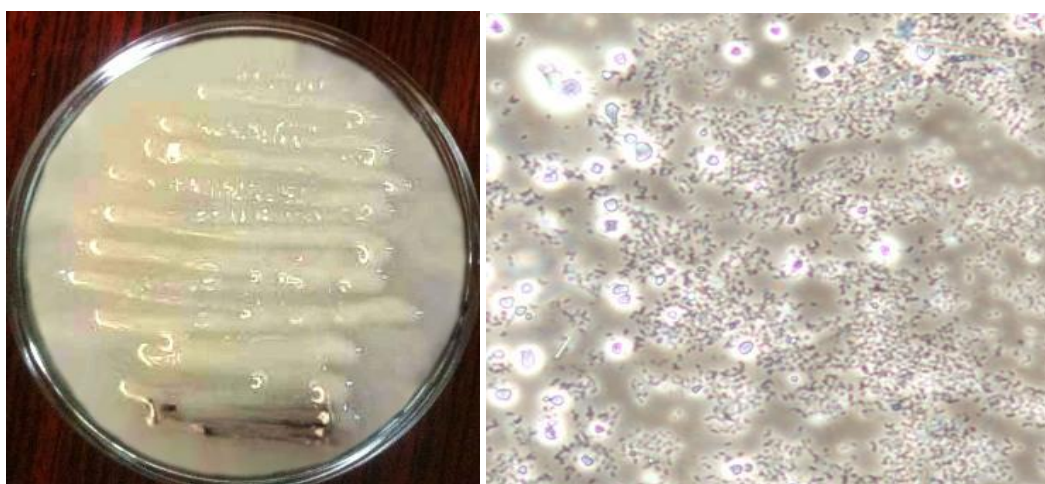


Рис.1. клубеньковые бактерии *Sinorhizobium fredii* на световом микроскопе "Olympus"

Чистоту культур клубеньковых бактерий проверяли визуально и под микроскопом. Микроскопический контроль проводился с препаратами живых и фиксированных окрашенных клеток с помощью светового микроскопа. В результате проведенной работы было выделено 10 чистые культуры клубеньковых бактерий. Культуральные и физиолого-биохимические свойства изолятов *Rhizobium sp.* изучали согласно общепринятым методам микробиологии и биохимии и методическим рекомендациям ВНИИСХМ РАСХН [8]. Исследование культурально-морфологических свойств бактерий показало, что при росте на среде МРС, бактерии образовывали бесцветные или молочно-белые слизистые колонии. Исследование морфологии ризобий показало, что все выделенные культуры были грамотрицательные, не образовывали спор и имели палочковидную форму клеток. При просмотре под микроскопом препаратов живых клеток бактерий отмечали их высокую подвижность. Установлено, что клетки бактерий были мелкими, полиморфными и с течением времени клетки принимали округлую форму. На фиксированных окрашенных препаратах четко просматривалась зернистость внутреннего содержания клеток клубеньковых бак-

терий. Исследование основных физиолого-биохимических свойств бактерий показало, что выделенные бактерии относятся к аэробам, не растут на мясопептонных средах и других белковых субстратах животного происхождения. По основным культурально-морфологическим и биохимическим свойствам бактерии были отнесены к двум родам – *Bradyrhizobium* и *Sinorhizobium*. Известно, что не все клубеньковые бактерии способны образовывать клубеньки на корнях растений сои [9]. В этой связи было проведено изучение способности выделенных бактерий к нодуляции и фиксации азота воздуха. Идентификацию ризобий проводили молекулярно-генетическим методом Сенгера, путем секвенирования 16S rRNA гена. Геномную ДНК выделяли из культуры бактерий и на основе изучения последовательности участка гена 16S rRNA с универсальными праймерами осуществляли идентификацию бактерий. Для ризобий был проведен филогенетический анализ путем сравнения нуклеотидной последовательности штамма с последовательностями 16S rRNA штаммов родственных бактерий из базы данных NCBI. В программе МЕГА 6.0 были построены филогенетические деревья с использованием Neighbor-Joining кластерного метода расчета генетических расстояний.

### Заключение

Таким образом, нами была выделена два вида клубеньковых бактерий из растений сои, быстрорастущие и медленно растущие бактерии. Рассмотренные в нашей статье результаты молекулярно-генетического анализа доказывают что в генетическом центре Центральной Азии встречаются быстрорастущие клубеньковые бактерии рода *Sinorhizobium fredii* вступающие в симбиоз с местными сортами сои и образуют азотфиксирующие клубеньки на корнях этих растениях.

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# EARTH SCIENCES

## ENVIRONMENTAL ASPECTS OF AGUA NUEVA AND PIMIENTA SHALE FORMATIONS DEVELOPMENT IN MEXICO

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### Abstract

At present, no type of energy generation can be considered entirely environmentally friendly. This article discusses the strategic role of shale hydrocarbons in Mexico's transition toward truly renewable energy sources. Until recently, the development of the Pimienta shale formation through hydraulic fracturing (fracking) faced an informal prohibition in Mexico. However, advances in extraction technologies successfully applied in the United States and Argentina—make it possible to achieve both economic profitability and environmental safety in shale hydrocarbon production. The implementation of shale projects in Mexico could become a key driver of national economic growth, ensure energy independence, and provide financial resources for future investments in genuinely “green” energy development.

**Keyword:** Mexico, shale hydrocarbons, Pimienta shale formation, Agua Nueva shale formation, hydraulic fracturing (fracking), catagenesis, shale gas, shale oil, production, energy transition, renewable energy, energy security, geothermal energy, electricity generation mix.

Despite various geopolitical and economic upheavals, global demand for energy continues to grow. According to the Global Energy Review 2025 published by the International Energy Agency (IEA), global energy demand in 2024 increased by 2.2 %, which is significantly higher than the average annual growth rate of the previous decade ( $\approx 1.3$  % per year) [1]. At the same time, “green” energy policies are becoming increasingly important worldwide. The central theme of the global environmental agenda the carbon footprint has, in many cases, become a subject of political and economic manipulation [2].

On the other hand, between 2035 and 2040, a sharp decline in oil production from conventional reservoirs is expected, which will likely lead to an increase

in oil prices. During this period, the world will also reach the peak production of shale oil, which, however, will be insufficient to fully offset the overall decline in output from aging conventional fields [4, 7].

The role of shale hydrocarbon resources will inevitably continue to grow due to their operational flexibility and the fact that their total resources and reserves are approximately twice those of conventional hydrocarbons.

This will shift the operational focus toward countries such as the United States, Argentina,

Mexico, Canada, Brazil, Russia, Poland, China, and Australia, all of which possess significant reserves of these types of hydrocarbon sources (**Fig. 1**) [3, 7, 9].

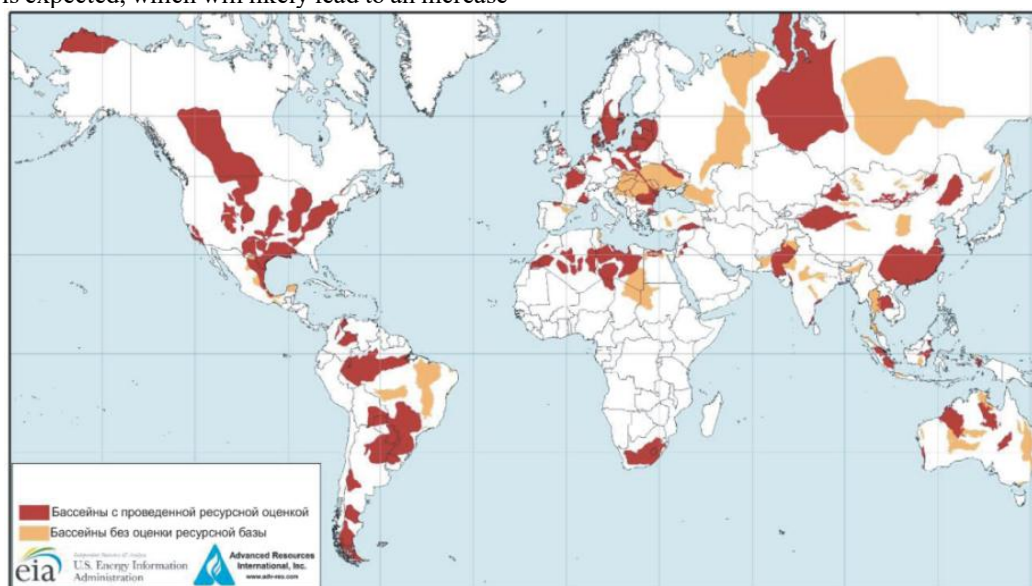


Fig. 1 - Distribution of the world's shale basins (Source: EIA) [3, 7]

It is expected that the peak of shale play activity will be reached between 2030 and 2040. Heavy oil and bitumen will begin to play an increasingly important role between 2030 and 2035, when their development will become economically feasible across all key parameters.

By 2040, the price of oil may reach 170 USD per barrel [3, 7]. Rising consumption combined with the limited availability of low breakeven reserves will exert additional upward pressure on prices.

At present (end of 2025), the oil price is around 63 USD per barrel, which makes the production of shale oil economically viable across all major shale plays in the United States, Canada, and Argentina.

Argentina is currently the only country in South America conducting commercial shale hydrocarbon production from the Vaca Muerta formation. As of mid-2025, production reached approximately 0.5 MMbbl/day of oil and about 875 MMft<sup>3</sup>/day of gas.

By 2025–2027, maintaining current production rates and oil prices, Argentina is expected to double its oil output and significantly increase gas production solely through shale development projects. In 2024, Argentina completely ceased oil imports.

The Eagle Ford shale formation extends into Mexican territory, occurring at approximately the same burial depths and under similar thermobaric conditions as on the U.S. side (Fig. 2). The assessment and subsequent planning of exploration and development were based on data from adjacent U.S. fields Red Hawk (shale oil), Blue Hawk (shale condensate), and Hawkville (shale gas) in southern Texas as well as from analogous fields and IHS (2014) data for wells drilled into the Eagle Ford / Agua Nueva formations on the Mexican side: Chucla-1, Durian-1, Emergente-1, and Montanes-1.

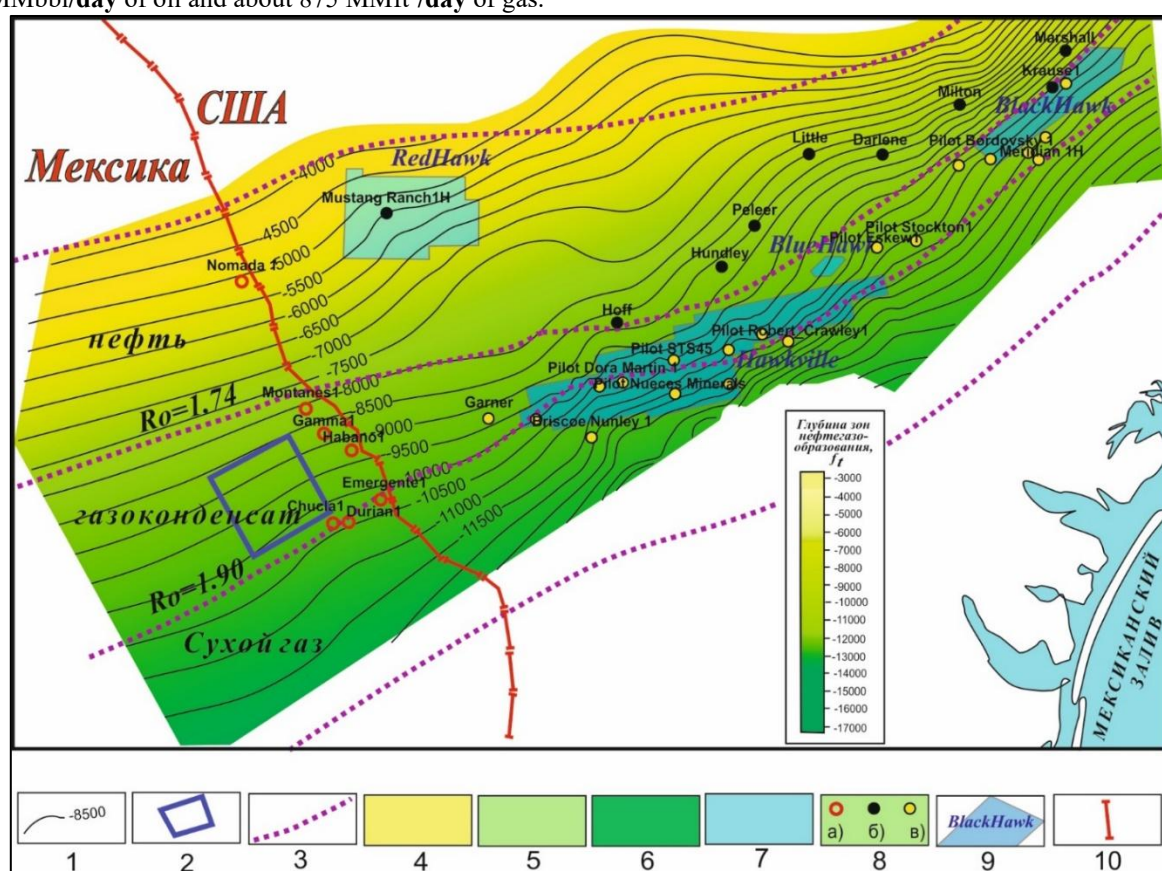


Fig. 2 – Zoning of hydrocarbon generation on the structural map of the Eagle Ford / Agua Nueva Formation top. 1 – contour lines, ft; 2 – pilot area; 3 – boundary isoressplines of the main hydrocarbon generation zones; 4 – area of source rocks within oil generation conditions (“oil window”); 5 – same, “gas-condensate window”; 6 – “gas window”; 7 – Gulf of Mexico offshore area; 8 – wells: (a) located in Mexico, (b) in oil fields, (c) in gas and gas-condensate fields; 9 – field boundaries; 10 – U.S.–Mexico state border [3, 8].

#### Experience

from the development of shale deposits worldwide allows identifying both the advantages and limitations of such projects in Mexico. The Agua Nueva shale formation demonstrates several favorable factors: a large areal extent, substantial volumes of organic-rich shale (high TOC), and low initial licensing costs.

Additional advantages include the presence of numerous developed shale fields across the U.S. border and the accumulated operational experience; minimal

exploration expenditures for non-structural traps; reliable geological data from earlier surveys in the region; and proximity to markets supported by relatively developed infrastructure. The presence of condensate and light oil ensures high project profitability regardless of gas prices.

However, several constraints may negatively affect shale development in this region. These include the

lack of domestic expertise in shale hydrocarbon exploitation, geological uncertainty regarding the properties and productivity of the Eagle Ford /Agua Nueva formations on the Mexican side, high initial production costs, and rapid decline rates of shale wells compared to conventional fields.

In addition, governmental restrictions on large-scale hydraulic fracturing (fracking) remain in place, limiting development potential. Reported initial production rates from shale wells in the U.S. Eagle Ford Formation range from 3.5–17.5MMft<sup>3</sup>/day of gas, 350–2800 bbl/day of condensate, and 210–850 bbl/day of oil [3].

The continuation of the Eagle Ford / Agua Nueva formation into Mexican territory exhibits high potential for natural gas and condensate production. Preliminary assessments suggest that the resource base in Mexico could reach hundreds of billions of cubic meters of gas and tens of millions of tonnes of liquid hydrocarbons [8].

The Pimienta Formation is the primary source rock in eastern Mexico, genetically linked to nearly all hydrocarbon accumulations in overlying Eocene, Oligocene, Miocene, Albian, Cenomanian, and Upper Jurassic strata hosted in conventional reservoirs and traps. Within the Tamaulipas, Veracruz, and Tabasco regions, the Pimienta Formation shows high potential for shale hydrocarbon development (**Fig. 3**) [6].

Nevertheless, its productivity remains poorly understood. Between 2010 and 2019, only 25 wells were drilled into the Pimienta Formation, including five horizontal wells with multistage hydraulic fracturing in the Tampico–Misantla Basin. These demonstrated average initial oil flow rates of approximately 900 bbl/day, with the Kaneni-1EXP well achieving a maximum rate of 1932 bbl/day after 17 stages of fracturing.

According to drilling data from wells targeting the Pimienta Formation within the western part of the Tampico Basin, an anomalously high geothermal gradient and abnormally elevated reservoir pressures have been identified in the Tithonian strata of the formation. These anomalies are attributed to geodynamic and thermal influences exerted by the Sierra Madre mountain system [6].

A high-standing viscoplastic magmatic focus, along with its convective eastward movement, caused extreme thermal effects and accelerated catagenesis (hypercatagenesis) of organic-mineral matter (OM) within the Pimienta Formation.

This process occurs in the contact zone beginning at depths of approximately 500 m, corresponding to stage MC<sub>5</sub> (the main gas-generation zone), thus bypassing the stages of protocatagenesis (PC<sub>1–3</sub>), early and middle mesocatagenesis (MC<sub>1–4</sub>), and the main oil-generation zone (MC<sub>1</sub>–MC<sub>2</sub>).



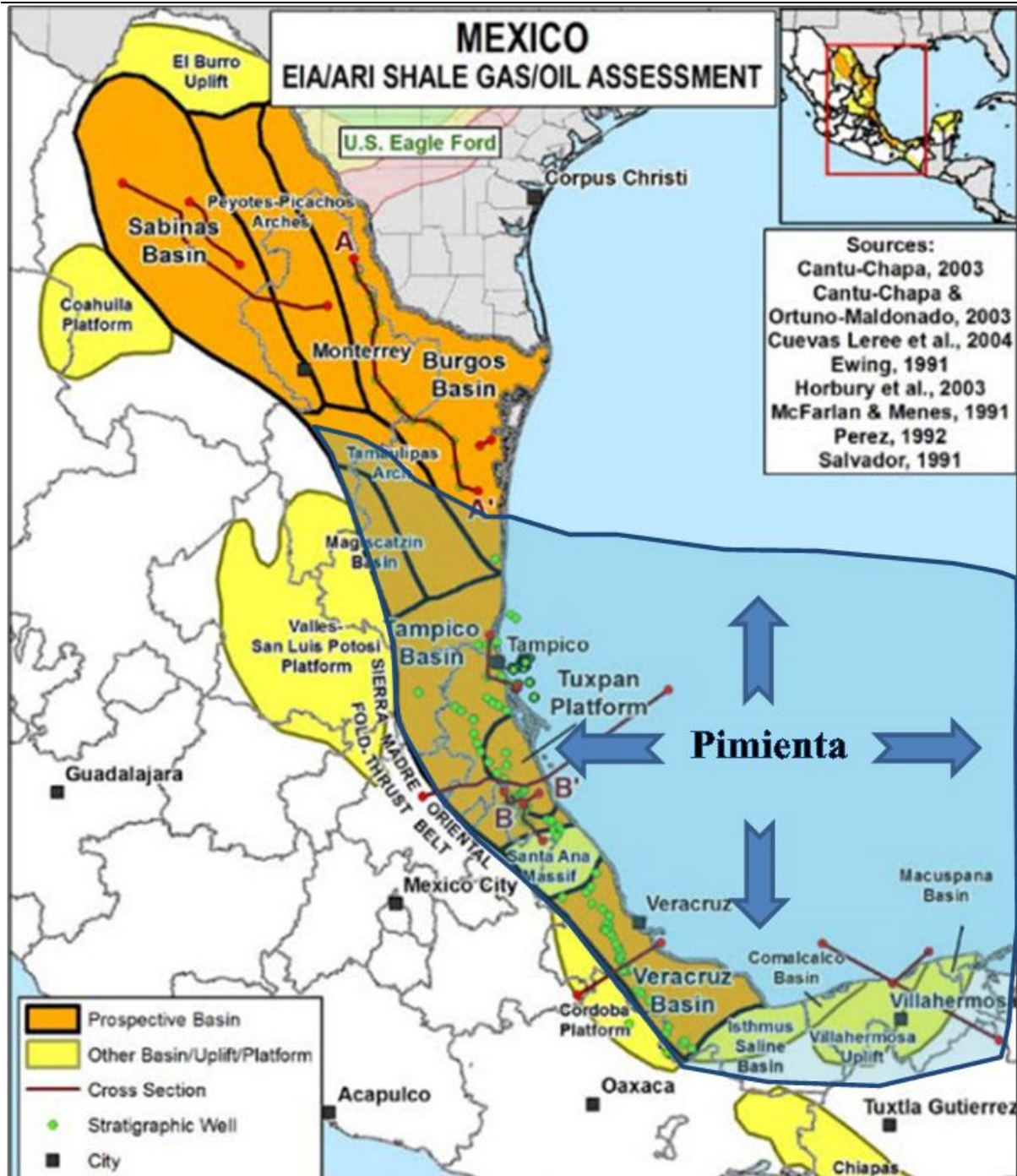


Fig. 3 – Oil and gas basins of eastern Mexico (onshore) where the Pimienta Formation is distributed [6].

Approximately along the coastline of the Gulf of Mexico runs the boundary between the main gas-generation and oil-generation zones. Beyond this boundary, the Pimienta Formation dips toward the offshore area, transitioning to the regional catagenetic scheme typical for the basin, characterized by a normal geothermal gradient [5].

According to drilling data from wells targeting the **Pimienta Formation** within the western part of the **Tampico Basin**, an **anomalously high geothermal gradient** and **abnormally elevated reservoir pressures** have been identified. These anomalies are caused by **geodynamic and thermal influences** from the **Sierra Madre mountain system** [6].

A high-standing viscoplastic magmatic focus and its convective eastward migration have resulted in extreme heating and accelerated catagenesis (hypercatagenesis) of organic-mineral matter (OM) within the Pimienta Formation. This thermal overprint occurs in the contact zone from depths as shallow as 500 m, corresponding to stage MC<sub>5</sub> (main gas generation zone), bypassing the stages of protocatagenesis (PC<sub>1-3</sub>), early and middle mesocatagenesis (MC<sub>1-4</sub>), and the main oil generation zone (MC<sub>1</sub>–MC<sub>2</sub>).

Approximately along the Gulf of Mexico coastline lies the boundary between the main gas- and oil-generation zones, beyond which the Pimienta Formation dips seaward and transitions into the regional catagenetic scheme characterized by a normal geothermal gradient [5].

The current zonation scheme of hydrocarbon generation and accumulation within the Pimienta Formation in the Tampico Province, compiled on the basis of deep-drilling data [10], is supported by results of hydraulic fracturing (HF) performed in five wells except for the deep interval corresponding to light oil ( $MC_2$ – $MC_3$ ).

In the Horcones-8127 and Furbero-4354 wells, light oil with a density of 37–38° API was obtained, indicating that the light-oil boundary shifts eastward, approximately along the Gulf coastline.

The boundaries of the main gas- and oil-generation zones are further confirmed by data from wells Pankiwi-1 (49°API) and Kaneni-1 (39°API).

Therefore, within the Tamaulipas and Veracruz provinces, production from the Pimienta Formation is expected to consist primarily of light oil with a density of 37–40°API, whereas in the western part, adjacent to the Sierra Madre system, production will mainly comprise dry gas and condensate.

The Pimienta Formation, which is approximately twice as thick as the Eagle Ford, combined with the im-

plementation of cyclic development strategies [3, 4] including repeated hydraulic fracturing of existing wells could yield higher cumulative production per well than in U.S. shale plays. This would reduce the number of new wells required and significantly improve the economic efficiency of shale hydrocarbon development in Mexico (Fig. 4) [6].

The initiation of shale development activities in the Pimienta Formation in Mexico by 2027 would allow commercial production to begin by 2028, with expected additional output of 0.4–1.3 MMbbl/day of oil by 2030.

By 2040–2050, production in the Tamaulipas, Veracruz, and Tabasco provinces could reach 2–3.3 MMbbl/day, sufficient to fully meet the country's domestic oil demand and to ensure Mexico's energy security until approximately 2060–2080, assuming the continuation of cyclic shale development under current consumption levels.

Starting from 2032, Mexico would be capable of exporting surplus oil to the United States and to countries of Central and South America [6].

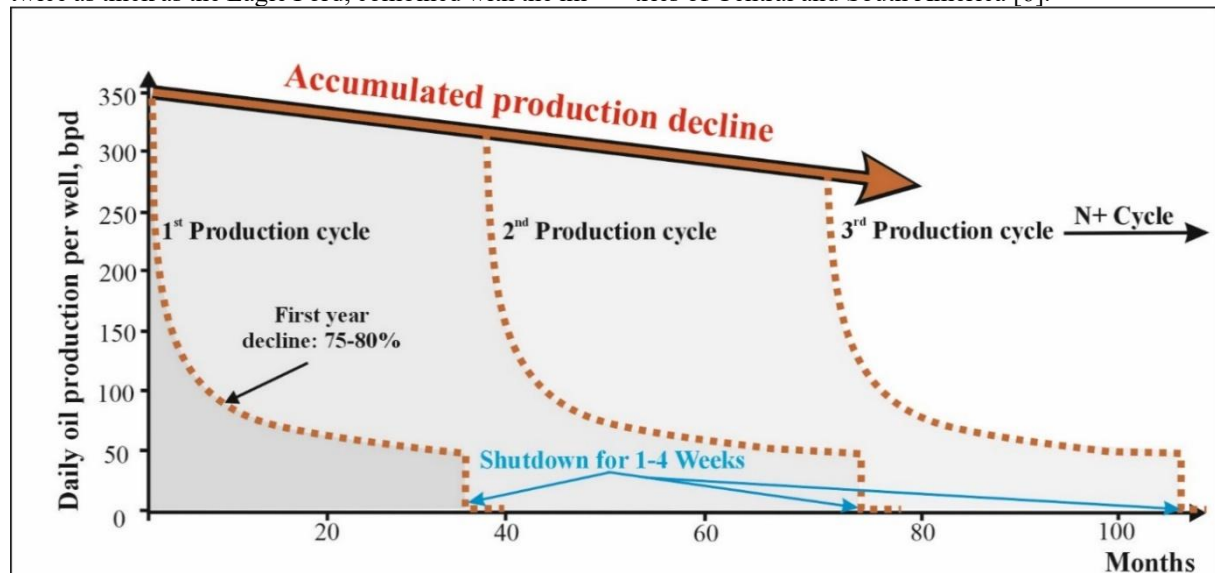


Fig. 4 – Principle of cyclic development of shale hydrocarbon reservoirs [3, 4, 6, 7, 8].

Considering that the Pimienta Formation lies within the gas-, condensate-, and light oil-generation zones, gas production (both dry and associated) may reach 2–4 Bft<sup>3</sup>/day by 2030. Together with the Eagle Ford / Agua Nueva shale gas development project extending into Mexico [7], this could ensure long-term energy security in the gas sector by 2033. Between 2032 and 2035, additional gas turbine power plants (GTTPs) may be commissioned in the Tampico, Veracruz, and Tabasco provinces, utilizing growing volumes of free gas production, which would significantly reduce electricity costs for consumers.

Until recently, there existed an informal governmental ban in Mexico on hydraulic fracturing (fracking), particularly on large-scale operations targeting the Pimienta Formation.

This restriction was primarily based on early environmental data from the first years of shale development in the United States, when serious environmental incidents related to extensive fracking operations were indeed observed.

An analysis of the environmental situation associated with shale play development in the United States and other regions of the world [2, 9] shows that modern advanced technologies, combined with higher oil and gas prices in recent years, now allow for both economically viable and environmentally safe shale hydrocarbon production through the following measures:

- Application of directional hydraulic fracturing to prevent fracture propagation into overlying aquifers.
- Reduction of the toxicity of fracturing fluids.
- Water treatment and reuse for hydraulic fracturing operations.
- Construction of seawater desalination plants to supply shale projects located near the Gulf of Mexico.
- Continuous environmental monitoring of groundwater, surface water, soil, and air.
- Seismic monitoring and tracer studies to assess the impact of industrial HF on induced seismicity within shale play regions.

The implementation of cyclic shale development could substantially reduce the number of producing wells, thereby decreasing the environmental footprint on subsurface resources and the surrounding environment [3, 7, 8].

The development of shale projects in the Tampico, Veracruz, and Tabasco states would create tens of thousands of jobs. The cities of Tampico, Veracruz, and Villahermosa could become major centers of Mexico's oil and gas industry. Veracruz, in particular, could evolve into a regional hub for shale hydrocarbon production and host a new refinery for processing shale oil volumes.

In Tampico, modernization of the existing refinery could allow for the processing of heavy oil, co-produced with shale hydrocarbons from the Pánuco, Altamira, and Ébano blocks.

To ensure adequate water supply for hydraulic fracturing, water treatment and reclamation plants may be constructed under a "1 liter for HF – 2 liters of purified water" principle to offset freshwater use.

These projects could significantly lower fuel and petroleum product costs in Mexico and support the export of petrochemical products to Central and South American markets. The main role of Mexico's government agencies in successfully implementing shale projects in the Tampico, Veracruz, and Tabasco regions should be to ensure competition and open market participation for drilling companies, reducing the average cost of drilling and completion to 5–8 MMUSD per well [6].

Mexico has declared a goal to achieve 45% of electricity generation from renewable energy sources (RES): solar, wind, hydro, and others by 2030 [11]. However, the implementation of renewable energy projects continues to face serious challenges, including aging transmission infrastructure, lack of energy storage facilities, regulatory uncertainty for private and foreign investors, high financial risks, and social and environmental conflicts at project sites.

While small-scale distributed solar projects (e.g., rooftop installations) remain economically viable even without direct subsidies due to tax incentives, large private renewable projects have stagnated since 2018, following the withdrawal of government subsidies. The federal government prioritizes building renewable capacity through the state-owned utility CFE, rather than through private investors. According to Ember (2024), the combined share of solar and wind power in Mexico's electricity generation is  $\approx 13\%$  [12].

A particularly ambitious initiative is the Plan Sonora, a government-led project to construct a 1 GW solar megastation. The first 120 MW phase was launched in 2023, yet the project faces public resistance, as it focuses primarily on infrastructure, logistics, and lithium extraction, rather than on community-based clean energy generation [13].

Although renewable energy sources - solar, wind, and hydro are often labeled as "clean," their environmental impacts are not eliminated, but rather transformed. For example, solar panel production requires significant resources, including rare earth metals, sili-

con, and high energy inputs for smelting and processing. Moreover, end-of-life management of photovoltaic (PV) panels remains an unresolved issue: panels contain toxic substances such as lead, cadmium, and tellurium, and their average service life is  $\sim 25$  years, after which most are discarded into landfills. According to the IEA/IRENA Task 12 report [13], by 2050, global PV waste could reach  $\sim 78$  MMtonnes. As noted in "How to tackle the looming challenge of solar PV panel recycling" (PNAS, 2025) [14], only  $\sim 10\%$  of retired PV panels are currently recycled, with the remainder sent to landfills, burial, or incineration. In Mexico's Jalisco state, the first PV recycling plant is still under development, projected to process 1,000 tonnes per year with investment of  $\sim 12$ – $15$  million pesos. As a non-profit initiative, the facility will likely require state subsidies, tax exemptions, or grants, as do most "green" projects at early stages.

Wind energy also entails significant material inputs - concrete, steel, and large land areas and can affect bird populations and local landscapes. In 2024, the share of wind energy in Mexico's total generation was approximately 6% [15]. Wind projects face grid, infrastructure, and land-rights challenges, as well as social resistance. At least two major projects: Gunaa Sicarú Wind Farm and Mareña Renovables Wind Project with a combined cost of around 1.5 BUSD, were cancelled due to local and indigenous community protests [16].

Hydropower in Mexico is undergoing structural decline, driven by aging infrastructure, water scarcity, community opposition, and lack of investment incentives. Hydroelectric plants are not fully "green," as they alter river ecosystems, disrupt fish migration, and affect local climates. They have also become less reliable energy sources, as seasonal flow variations can cause 30–50% output reductions during drought years. According to CONAGUA, reservoir levels have decreased by 20–30% on average over the past decade, particularly in central and northern states [17].

The La Parota project (Guerrero) was suspended after protests over the potential flooding of 17 villages and the relocation of  $\sim 25,000$  residents. Such conflicts have created a public perception of hydropower as "socially risky", especially following failed wind energy cases (e.g., Oaxaca). According to CFE (Comisión Federal de Electricidad), about 70% of Mexico's hydropower plants require major rehabilitation, but no funding has been allocated. National energy strategies have shifted priority toward solar and wind, which require less land and fewer social negotiations.

Promising opportunities remain only for small-scale hydropower (1–10 MW) in southern mountain regions with stable river flow and minimal resettlement needs.

All of Mexico's nuclear power generation is concentrated in a single operating facility - the Laguna Verde Nuclear Power Plant (Veracruz), constructed in the 1980s with U.S. assistance. The plant's total capacity is 1640 MW (two GE BWR-5 reactors). It remains fully dependent on foreign technology, equipment, and nuclear fuel, primarily from the United States and Japan. According to the IAEA and independent industry

reviews, the average cost of electricity generation at Laguna Verde is 100–120 USD per MWh, compared to 40–50 USD per MWh for large-scale solar power projects [18, 19].

Thus, nuclear energy remains the least competitive low-carbon source in Mexico due to high capital costs, fuel import dependency, and the absence of economies of scale. There is still no centralized repository for radioactive waste; spent fuel is stored temporarily on-site at Laguna Verde. Moreover, Mexico lacks national legislation defining a long-term radioactive waste management strategy.

Thus, the transition to “green energy” is not so much a path toward complete environmental purity as it is a search for balance between energy security, sustainability, and minimal ecosystem disruption.

According to 2019 data, Mexico ranks sixth globally after the United States, the Philippines, Indonesia, Turkey, and New Zealand—in installed geothermal power capacity, which is estimated at 951 MW. The largest geothermal plants, Cerro Prieto II and Cerro Prieto III, each have an installed capacity of 220 MW. Although geothermal energy is classified as *renewable and green*, studies [20, 21] indicate that in the area of the Cerro Prieto geothermal complex (Baja California, Mexico), mercury concentrations in surface soils range from 0.01 to 0.26 mg/kg. The same studies report that geothermal brine leaks lead to elevated concentrations of elements such as arsenic (up to 8 mg/L) and boron compounds (up to 125 mg/L) both within and up to 10 km beyond the geothermal field. These findings suggest that geothermal projects, despite being labeled as “renewable and clean,” can pose localized environmental risks, including soil and water contamination by

heavy metals and toxic elements. For Mexico where geothermal fields are situated in volcanically active regions, often adjacent to rural communities such research holds particular importance.

Mexico has made official commitments to reduce greenhouse gas (GHG) emissions by approximately 35% by 2030 relative to the *business-as-usual (BAU)* scenario. Environmental issues, however, are often subject to politicization and speculative interpretation, overshadowing scientific evidence. Recent studies increasingly highlight that higher atmospheric CO<sub>2</sub> concentrations can in fact promote plant biomass growth, a phenomenon known as the CO<sub>2</sub> fertilization effect. According to Zhu et al. (2016), elevated CO<sub>2</sub> concentrations exert a strong stimulatory influence on photosynthesis, leading to a global increase in vegetation biomass by approximately 10% over the past three decades. This effect has been further confirmed by other studies (Donohue et al., 2013; Le Quéré et al., 2022), which observed accelerated biomass accumulation and increased leaf area index particularly in semi-arid regions of the world.

The Mexican government’s environmental commitments, shaped largely by the global green agenda, contrast with current economic and technical realities. At this stage, shale hydrocarbon projects represent a more economically and environmentally rational option. The profitability of shale projects is considerably higher: shale wells typically achieve full payback within 1–2 years, whereas solar and wind farms require 10–15 years to reach break-even.

Natural gas-fired power plants (Fig. 5) produce more than 60% of Mexico’s total electricity generation.

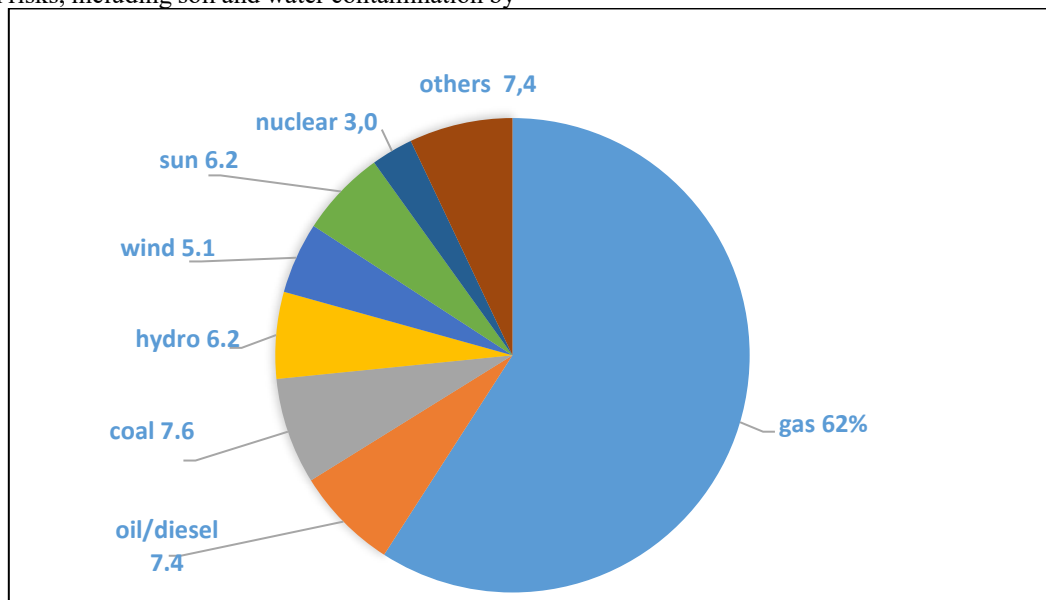


Fig. 5 – Electricity generation mix in Mexico (%), IEA, Mexico 2024 [22]

At the same time, Mexico imports most of its gas from the United States - about 5.5 Bft<sup>3</sup>/day (2019) through pipelines and receives liquefied natural gas (LNG) from the U.S., Qatar, Nigeria, and Peru. This occurs despite the country’s significant untapped domestic reserves of natural (shale) gas. Such a situation creates a paradoxical dependency on external suppliers, despite the availability of local resources. It

reinforces Mexico’s energy vulnerability and price exposure to the U.S. market while simultaneously hindering the development of a self-sufficient national energy sector and slowing the transition toward genuinely sustainable energy that is, energy systems with minimal environmental externalities. The electricity



generation mix reflects the structure of power generation by source that is, which technologies actually deliver electricity to the national grid (**Table 1**).

Its composition directly mirrors a country's dependence on fossil fuels, the extent of renewable energy

integration, climatic and seasonal conditions (e.g., variations in hydropower output), and the technological maturity of its power system (for example, the share of modern combined-cycle gas turbines compared to outdated fuel-oil units).

Table 1

| Year        | Gas %     | Oil/Diesel, % | Coal, %  | Hydro, % | Wind %   | Sun %    | Nuclear % | Others (geo-, bio-)% | Source                                                |
|-------------|-----------|---------------|----------|----------|----------|----------|-----------|----------------------|-------------------------------------------------------|
| 2000        | 16.7      | 49.2          | 9.2      | 17.3     | 0        | 0        | 4.5       | 3.1                  | (SENER). <i>Balance Nacional de Energía 2000</i>      |
| 2003        | 54.5      | 12.3          | 13       | 14.5     | 0        | 0        | 2.4       | 3.2                  | SENER). <i>Balance Nacional de Energía 2003</i>       |
| 2010        | 50.9      | 15.6          | 13.2     | 15.1     | 0.1      | 0        | 2.4       | 2.7                  | <i>Balance Nacional de Energía 2010</i> (SENER) + IEA |
| 2015        | 59.9      | 10.1          | 10.9     | 9.9      | 3        | 0.3      | 4         | 1.9                  | CEICData. Mexico, (SENER 2016)                        |
| 2020        | 60        | 10            | 5        | 8.5      | 6        | 3        | 4         | 3.5                  | <i>Our World in Data / IEA 2020</i>                   |
| 2022        | 59        | 8             | 8        | 10       | 6        | 6        | 3         | 0,3                  | <i>SENER PRODESEN 2023-2037</i>                       |
| 2023        | 61        | 7             | 5        | 9        | 9        | 7        | 3         | 1                    | IEA / Ember 2024                                      |
| 2024        | 62        | 7.4           | 7.6      | 6.2      | 5.1      | 6.2      | 3         | 2.5                  | (IEA). Mexico                                         |
| <b>2035</b> | <b>75</b> | <b>4</b>      | <b>3</b> | <b>4</b> | <b>5</b> | <b>5</b> | <b>1</b>  | <b>3</b>             | <b>Author's forecast</b>                              |

In the case of Mexico, the electricity generation mix is a truly key indicator, as electric power accounts for approximately 20 % of the nation's final energy consumption. The structure of electricity generation is closely linked to the energy policies of the state-owned utility CFE and the Ministry of Energy (SENER). However, the electricity mix only shows the composition of power generation—what fuels and technologies produce electricity.

Electricity itself represents only one-fifth of total energy use, while the remaining  $\approx 80$  % is associated with other sectors:

- Transport: gasoline, diesel, jet fuel, natural gas, biofuels;
- Industrial heat and steam: oil, coal, and gas used for heating, smelting, cement, and metal production;
- Residential and commercial energy: cooking and heating fuels such as gas, wood, coal, and biomass;
- Agriculture and extractive industries: diesel, oil, and gas used off-grid.

Indeed, the “green transformation” in Mexico (as elsewhere in the world) primarily concerns the electricity sector that is, how electricity is produced. Other sectors: transportation, industry, heating, and agriculture remain largely dependent on fossil fuels. Integrating renewable energy sources (RES) requires new transmission lines and energy-storage facilities, which means additional costs. Solar projects frequently encounter community resistance related to land disputes and leasing conflicts. In contrast, for shale hydrocarbon pro-

jects, the pipeline and transmission infrastructure already exists (the northern regions are connected to Texas), and no new gas-pipeline construction is required, since new gas-fired power plants (GTPPs) can be built within producing regions such as Tamaulipas, Veracruz, and Tabasco. Land for shale projects is often state-owned, and Pemex, the national oil company, obtains access through federal regulation.

Renewables depend on sunlight and wind, require backup generation capacity, and typically rely on government subsidies. Shale gas, by contrast, provides a stable and high-capacity source of electricity generation and reduces Mexico's energy dependence on the United States. The development of the Agua Nueva and Pimienta shale formations, beginning in 2027, could allow Mexico to produce an additional 3–5 Bft<sup>3</sup>/day of gas by 2030 and to achieve long-term gas self-sufficiency by 2033, even enabling exports to neighboring Latin American countries. By 2032, up to 75 % of Mexico's electricity could be generated from natural gas, currently the cleanest and most efficient fossil fuel available.

Therefore, the most effective and economically sound energy policy for Mexico in the coming decades should focus on the development and production of shale hydrocarbons. This strategy will strengthen technological capacity and create a foundation for a gradual transition toward truly renewable, environmentally safe, and low-waste energy sources, including hydrogen, electromagnetic, and nano-other energy systems [23].



### Conclusion

Mexico's energy future will depend on achieving a **rational balance between environmental sustainability and national energy security**.

While the global green agenda emphasizes the rapid transition to renewable energy sources, **technological, economic, and infrastructural realities** demonstrate that **fossil fuels—particularly shale hydrocarbons—will remain essential** for the country's development in the medium term. The exploitation of the **Pimienta** and **Agua Nueva** shale formations offers Mexico a unique opportunity to strengthen its **domestic energy base, reduce dependency on imports, and secure the financial resources** needed for the long-term development of truly clean energy technologies.

At the same time, the experience of the **United States** and **Argentina** shows that modern shale development can be both **economically viable and environmentally responsible** when advanced technologies are applied—such as **directional hydraulic fracturing, water recycling, and environmental monitoring**.

For Mexico, the adoption of these practices would not only minimize environmental risks but also generate **tens of thousands of jobs** and stimulate **technological innovation** across related industries.

By 2033, the **combined production** from shale formations could **fully ensure Mexico's gas self-sufficiency**, and by 2040–2050 the country may become a **net exporter of hydrocarbons**, achieving **energy independence** and **price stability** for decades ahead.

In the long run, the revenues and technological expertise gained from shale energy projects can provide the foundation for a **gradual, science-based transition to next-generation renewable systems** including **hydrogen, electromagnetic, and nano-ether technologies**.

Thus, Mexico's strategic path lies not in rejecting hydrocarbons, but in **integrating them intelligently** into a diversified, sustainable energy framework that balances **economic efficiency, environmental responsibility, and technological progress**.

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# ECONOMIC SCIENCES

## OPPORTUNITIES TO IMPROVE ROAD, TRANSPORT AND PORT COOPERATION BETWEEN CHINA, MONGOLIA, AND RUSSIA

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### Abstract

In this article we analyze the implementation of the Mongolian government's policies on the development of roads, transport, logistics, and ports in Mongolia, evaluate the current state of development of the roads, transport, and ports sectors, and identify the problems facing these sectors. Based on these analyses, a development concept for the roads and transport sectors of Mongolia is proposed, which aims to connect the central and eastern vertical corridors based on the location of mining and water resources through railways and highway networks, and we identified the need to increase the capacity of ports such as Altanbulag, Sukhbaatar, Khushgiin Khundi, Sainshand, Zamyn-Uud, Ereentsav, Choibalsan, and Bichigt. We also propose the construction of hard and soft infrastructure necessary to connect dry ports of Mongolia with sea ports of China and Russia.

**Keywords:** China, Russia, Mongolia, transport hub, eastern corridor, railways, highways, roads, air transport, dry ports, seaports, connectivity, soft and hard infrastructure.

### 1. Policies and activities implemented by the Mongolian government regarding transport, logistics, and port development

In order to establish a dry port on its territory, Mongolia joined the Intergovernmental Agreement on Dry Ports, ratified by the Mongolian State Great Khural on February 5, 2016, and on April 23, 2016, Altanbulag, Ulaanbaatar, Sainshand, and Zamyn-Uud were declared dry ports, and Choibalsan was declared a potential dry port.

Mongolia's long-term development policy "VISION-2050", approved in 2020, sets the following goals: "Implement a multi-center city system, build satellite cities starting with the construction of new cities such as "Aero City" and "Maidar City", fully connect them to the engineering network, intensify housing construction, fully put the new international airport in Ulaanbaatar into operation, and develop it into a North Asian passenger and cargo transportation hub and integrated logistics center." A Northeast Asian integrated freight transportation hub will be established in Aerocity in the Khushgiin Valley, based on a new international airport, the newly planned Altanbulag-Zamyn-Uud Bogd Khan railway, the AN-3 highway, and major energy network projects. Within this framework, specialized mega warehouses will be built in Argalant-Emeelt, Bagakhangai, and Nalaikh, cargo distribution centers will be established in 9 locations in Ulaanbaatar, and logistics centers will be established in Bayan Urtuu, Argalant-Emeelt, and Aero City.[1, p.23]

Within the framework of implementing these goals, the "New Revitalization Policy" proposes to

implement the following goals of "Develop hard and soft infrastructure of ports to increase cargo and passenger throughput capacity, increase exports, gradually connecting border ports with railways and paved roads, improve the competitiveness of transport and logistics by improving freight traffic, and create the basic conditions for becoming a transit country in the future. Improve the organization of Mongolian airspace and airspace utilization, increase the number of transit aircraft, and gradually continue the liberalization of air transport to create a freight transport hub which will support the tourism sector. Based on Mongolia's regional development concept, increase trade turnover by gradually establishing free economic zones and dry ports.[2, p.7]"

As such, measures are being taken to increase the carrying and throughput capacity of road and transport infrastructure, and to eliminate road and transport congestion and bottlenecks.

Subsequently, the Government approved Resolution No. 327 on measures to be taken regarding the "Five Circles of New Revival" on September 1, 2023. Within the framework of these five circles, the goals are to build roads connecting inter-provincial and border crossings, and to connect border crossing roads connecting Russia and China with paved roads in 5 vertical and 2 horizontal directions, and to expand them in stages.

### 2. Current condition of Mongolia's road and transport sector

As a landlocked country located between two superpowers, Russia and China, international trade and

transport via land and sea ports are highly dependent on the socio-economic and political environment of the two neighbors and their international political, economic and geopolitical situation. The majority of Mongolia's exports enter the Russian and Chinese markets through Zamyn-Uud, Gashuun Sukhait, Bichigt, and Altanbulag ports, while the majority of Mongolia's domestic imports are through Zamyn-Uud (via railway and motorway), Altanbulag (via motorway) port, and into Ereen Port in China and Khiagt Port in Russia. As the volume of international supply and demand increases, the volume of transit and import and export cargo passing through Zamyn-Uud, Ulaanbaatar, and Altanbulag ports has increased dramatically. However, the transport and logistics capabilities of these ports are insufficient to meet the growing needs of international trade, transit and transport.

From 2013 to 2023, the volume of cargo transported by the Mongolian road transport sector increased by 59.9 million tons (240%), the volume of cargo transported by rail increased by 11.3 million tons (58.8%), and the volume of cargo transported by road increased by 48.6 million tons (330%). Compared to

the volume of cargo transported by air reaching 4 thousand tons in 2013, it increased by 8.6 thousand tons (210%) by 2023. This positive impact is believed to be the result of the new airport in the Khushgyn Valley, which came into operation in 2018 and increased the volume of international cargo transported through it.

Considering the cargo turnover by type of transport: In 2013, railway freight turnover accounted for 49.6%, road freight turnover for 50.3%, and air freight turnover for 0.009% of the total freight turnover in the country, while in 2023, railway freight turnover accounted for 31.6%, road freight turnover for 68.3%, and air freight turnover for 0.008%. While the share of railway freight turnover decreased from 2013 to 2023, the share of road freight turnover increased. This can be considered as a shift in freight turnover from railway to road nationwide.

In other words, the increasing contribution of road to the country's economy can be understood as the result of measures taken by the Mongolian government to increase the capacity of the national and local road network. See Table 1 for indicators of the road and transport sector in Mongolia.

Table 1.

Road and transport sector indicators in Mongolia

| Indicator                              | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023     |
|----------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| Load carried (thousand tons)           | 42361.4 | 44636.2 | 32197.3 | 40400.2 | 53983.4 | 67802.9 | 68997.5 | 60297.8 | 49238.1 | 60813.4 | 102302.1 |
| Railway                                | 21035.5 | 21118.6 | 19150.8 | 19989.1 | 22765.1 | 25763.3 | 28143.0 | 29840.1 | 31261.4 | 27680.9 | 32362.6  |
| Roadway                                | 21321.9 | 23514.2 | 13043.7 | 20406.2 | 31212.9 | 42033.8 | 40848.8 | 30455.0 | 17970.3 | 33075.6 | 69930.9  |
| Airway                                 | 4.1     | 3.4     | 2.8     | 4.9     | 5.4     | 5.8     | 5.8     | 2.7     | 6.4     | 12.9    | 8.6      |
| Freight turnover (million tons/km)     | 14641.9 | 17419.5 | 13844.3 | 16619.4 | 19167.8 | 21969.5 | 23601.8 | 23861.0 | 20674.6 | 17534.1 | 25963.4  |
| Railway                                | 12076.5 | 12473.7 | 11462.6 | 12371.0 | 13493.3 | 15315.3 | 17384.1 | 19167.6 | 18345.1 | 14910.2 | 18851.0  |
| Roadway                                | 2555.8  | 4936.4  | 2374.0  | 4236.2  | 5661.3  | 6640.6  | 6203.8  | 4685.3  | 2313.9  | 2591.9  | 7088.1   |
| Airway                                 | 9.6     | 9.4     | 7.7     | 12.2    | 13.2    | 13.6    | 13.9    | 8.1     | 15.6    | 32.0    | 24.3     |
| Number of passengers (million people)  | 307.9   | 344.2   | 260.3   | 264.4   | 216.1   | 197.0   | 173.0   | 126.5   | 107.1   | 146.3   | 147.0    |
| Railway                                | 3.8     | 3.3     | 2.8     | 2.7     | 2.6     | 2.6     | 3.0     | 2.0     | 0.4     | 2.4     | 2.2      |
| Roadway                                | 303.4   | 340.2   | 256.5   | 260.7   | 212.2   | 193.0   | 168.4   | 124.1   | 106.5   | 143.0   | 143.1    |
| Airway                                 | 0.8     | 0.7     | 1.0     | 1.0     | 1.3     | 1.4     | 1.6     | 0.5     | 0.2     | 0.9     | 1.7      |
| Waterway                               | 0.0     | 0.0     | 0.1     | 0.0     | 0.0     | 0.0     | 0.0     | 0.0     | 0.0     | 0.0     | 0.1      |
| Passenger turnover (million person/km) | 4604.2  | 5235.4  | 4931.6  | 4988.5  | 5434.7  | 6598.1  | 7146.2  | 3416.9  | 1563.4  | 4445.3  | 6494.5   |
| Railway                                | 1394.4  | 1194.5  | 996.7   | 955.5   | 973.2   | 993.7   | 1111.5  | 579.3   | 90.7    | 701.5   | 799.3    |
| Roadway                                | 1897.5  | 2793.0  | 1940.5  | 1959.9  | 2040.9  | 2919.9  | 2925.1  | 2178.0  | 1023.0  | 1914.9  | 1813.2   |
| Airway                                 | 1311.8  | 1247.1  | 1993.5  | 2072.4  | 2420.2  | 2684.2  | 3109.4  | 659.6   | 449.4   | 1828.4  | 3880.8   |
| Waterway                               | 0.5     | 0.8     | 0.9     | 0.7     | 0.4     | 0.3     | 0.2     | 0.0     | 0.4     | 0.5     | 1.2      |

|                                                |        |        |       |        |        |        |        |        |        |        |        |
|------------------------------------------------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| Total transportation revenue (billion tugriks) | 1045.0 | 1038.3 | 987.9 | 1191.6 | 1422.2 | 1754.4 | 2384.6 | 2025.0 | 2078.1 | 4435.8 | 6744.7 |
| Railway                                        | 421.4  | 427.9  | 387.9 | 436.9  | 530.0  | 616.0  | 708.6  | 770.1  | 766.3  | 748.2  | 1124.9 |
| Roadway                                        | 376.2  | 363.8  | 345.1 | 467.2  | 506.4  | 695.9  | 1177.2 | 1090.8 | 1111.3 | 3174.0 | 4676.4 |
| Airway                                         | 247.3  | 246.2  | 254.3 | 287.3  | 385.5  | 442.3  | 498.7  | 164.1  | 200.1  | 513.0  | 941.9  |

Source: Statistical database of the National Statistics Committee of Mongolia, [www.1212.mn](http://www.1212.mn)

Table 1 shows that from 2013 to 2023 the total passenger traffic transported nationwide decreased by 1.8 million person per km (41.1%), which includes a decrease in railway passenger traffic by 595 thousand person per km (42.7%) and a decrease in road passenger traffic by 84.3 thousand person per km (4.4%), while air passenger traffic increased by 2.5 million person per km (300%) and water passenger traffic increased by 700 person per km (2.4%). These increases in air passenger traffic and water passenger traffic are due to the establishment and operation of the new airport in the Khushgyn Valley and the increase in the number of people traveling on the Sukhbaatar ship in the Khuvsgul Lake. For example, while in 2013, railways accounted for 30.2%, roads for 41.2%, air for 28.5%, and waterways for 0.01% of Mongolia's total passenger transport turnover, in 2023, railways accounted for 12.3%, roads for 27.9%, air for 59.7%, and waterways for 0.01%. This means that the percentage of passenger turnover of railways and roads is decreasing, while the percentage of air passenger turnover is increasing. This is due to the increase in the number of foreign and domestic flights in recent years.

In 2013, the revenue of the Mongolian road and transport sector was 1 billion tugriks, while in 2023 it reached 6.7 billion tugriks, which is an increase of 5.6 billion tugriks, or 6.5 times. In 2013, railway revenue accounted for 40.3%, road revenue for 35.9%, and air revenue for 23.6% of Mongolia's road and transport

sector revenue, while in 2023, railway revenue accounted for 16.7%, road revenue for 69.3%, and air revenue for 13.9%. The decrease in railways share and the increase of almost 2 times in the road revenue share can be attributed to the quality improvement of road infrastructure, especially the opening of the Bayankhongor, Gobi-Altai, and Khovd highways to the western provinces had a tangible impact on the increase in road transport revenue.

Thus, the volume of transported cargo and passenger traffic increased throughout Mongolia. During this period, while the volume of cargo traffic on Mongolian roads, air routes, and waterways increased, the volume of railway freight traffic tended to decrease. We believe that this is due to the deteriorating infrastructure of the railway, outdated machinery and equipment, insufficient capacity of stations, logistics centers and terminals, and the lack of electrification of the railway.

### 3. Current status of Mongolia's transport brokerage and logistics sector

Mongolia has a total of 39 ports, including 6 railway ports, 4 air ports, and 27 road ports. However, of these only 7 road, 3 rail, and 1 by air ports are operational. According to the World Port Logistics Capacity Index, Mongolia ranks 130th out of 160 countries[3,p.27].

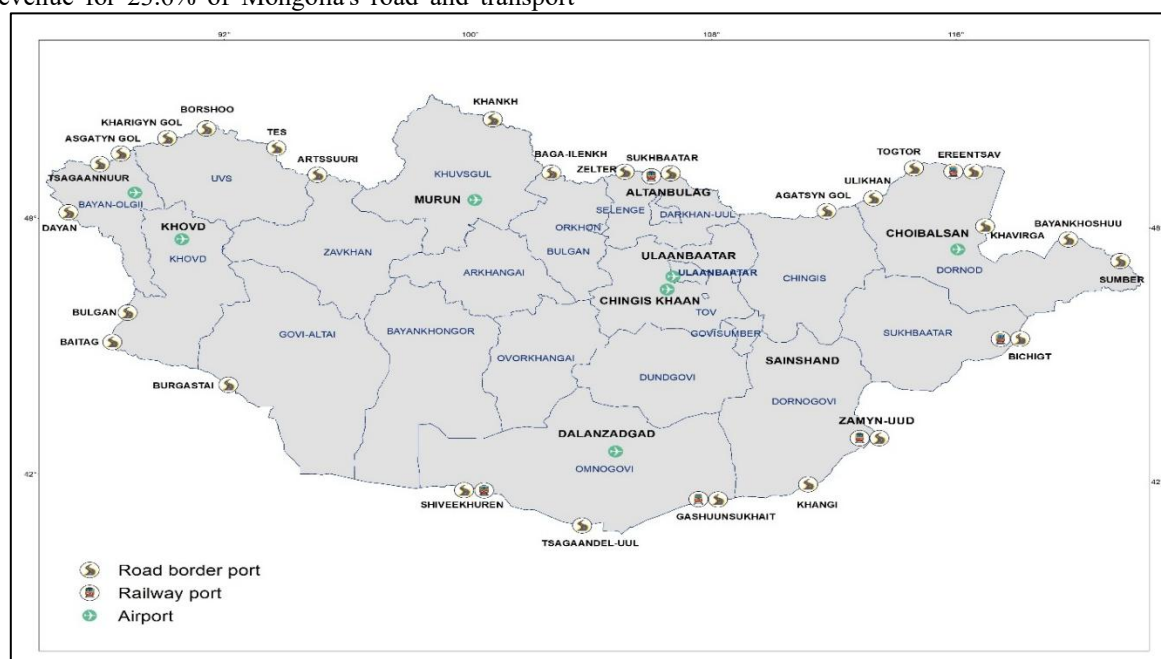


Figure 1.  
Current status of Mongolian ports

Currently, there are over 300 registered transport and logistics companies in Mongolia, of which about 120 companies are engaged in permanent operations with about 10000 people working in this sector. 90 percent of Mongolia's total import cargo passes through three ports: Zamyn-Uud, Altanbulag, and Sukhbaatar[3,p.34].

Mongolian imported goods arrive at the Tianjin port of China and are transported through the territory of China, transferred from narrow gauge to wide gauge at the Zamyn-Uud port through Ereen port, and then transported across the territory of Mongolia, delivered to 11 terminals in Ulaanbaatar. After they reach Ulaanbaatar, the goods are unloaded from the wagon at the container yard and passes through customs inspection. Once the recipient pays the tax, the cargo is received, and distributed by car to wholesale and retail centers, and the cargo is delivered to the final consumer. If the recipient cannot pay the tax, the cargo is stored in a bonded warehouse.

After the goods arrive in Ulaanbaatar, there is an urgent need to transport the goods and distribute them to the recipients in a short time. It has become necessary to improve the efficiency of services at Tianjin Port with the cooperation of the Chinese authorities, improve the capacity of the logistics center based on mixed transport, and establish a new logistics center in

an optimal location when organizing services in Zamyn-Uud and Ulaanbaatar.[4,p.57]

Thus, the Mongolian State Congress and the Government are taking necessary measures to develop the transport and logistics and port sectors. One such example is the "Port Revitalization Policy", which prioritizes the development of hard and soft infrastructure of ports, increasing their throughput capacity, laying the foundation for the development of mixed transport, increasing domestic and transit transport flows, and establishing free economic zones. In doing so, the government is focusing on implementing the goals of establishing a free economic zone based on the Khushgyn Valley Airport and establishing an international transport logistics center by building the Bogdhan Railway.

There is a need to propose a new concept of road and transport development based on Mongolia's mineral deposits and groundwater resources. To this end, it is considered necessary to connect the central vertical corridor with the eastern vertical corridor by rail and road way. This can be realized by building a new 540 km railway between Baganuur and Choibalsan, along with the construction of a 394 km railway between Sainshand, Baruun-Urt, and Khoot[4, p.85].

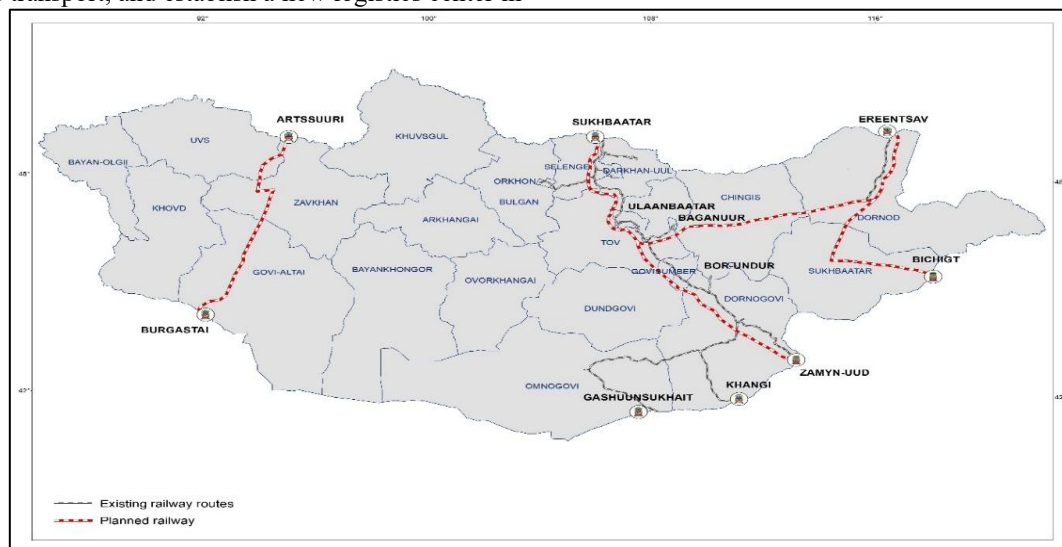


Figure 2.

*Mongolia's road and transport development concept*

*Source: Image created based on the results of dry port research by Davaasuren A.*

As can be seen from Figure 2, the development concept of Mongolia's road and transport sector should be based on the location of mining and water resources. Additionally, there is a need to connect the central and eastern vertical corridors by rail (a fully electrified second pair of railways connecting Zamyn-Uud, Khushgyn Valley, and Sukhbaatar along the main line of the Ulaanbaatar railway, including the Bogdhan railway, and a fully electrified railway connecting Bichigt, Khoot, Choibalsan, and Ereentsav) and by road (the vertical axis Asian Highway AN3 highway along the central corridor, the horizontal axis Asian Highway AN32 highway), and to increase the capacity of ports such as Altanbulag, Sukhbaatar, Khushgyn Valley,

Sainshand, Zamyn-Uud, Ereentsav, Choibalsan, and Bichigt by 2-3 times [5, p. 19].

### Conclusion

While the volume of road, air and passenger traffic transported throughout Mongolia is increasing, the volume of rail freight traffic has decreased. This is due to the deterioration of the railway infrastructure, outdated equipment and machinery, insufficient capacity of stations, intermodal logistics centers and terminals, and the lack of electrification of the railways.

The capacity of ports along the Central Corridor of Mongolia has become overused and can no longer cope with the load. Additionally, projects to increase the throughput capacity of Mongolian ports



implemented by the World Bank, ADB and other international organizations are not aimed at improving the technical, administrative, organizational management, ownership and human resource capacity of UN-locked dry ports, and are therefore ineffective.

Hence, there is an urgent need to review Mongolia's road, transport, logistics, and port development vision, connect our country's ports based on mineral and water resources with mixed transport infrastructure, improve the throughput capacity of ports, and connect them with seaports in Russia and China.

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# PEDAGOGICAL SCIENCES

## IMPROVING STUDENTS' ORAL SPEAKING SKILLS THROUGH THE COMMUNICATIVE APPROACH

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### Abstract

The development of authentic and effective oral speaking skills remains a primary pedagogical challenge and objective in second and foreign language education. This article presents a comprehensive theoretical review and a practical framework demonstrating the efficacy of the Communicative Approach (CA) in transcending the traditional dichotomy between linguistic knowledge (accuracy) and practical usage (fluency). Drawing upon extensive literature, this analysis establishes that CA—characterized by student-centered tasks, collaborative learning, and culturally responsive content—is the optimal methodology for cultivating the functional competence required for real-world interaction. Furthermore, the paper discusses how methods like Project-Based Learning (PBL) and an emphasis on intercultural communication act as powerful accelerators for oral proficiency, transforming the classroom into an authentic environment for linguistic practice. The findings underscore a pedagogical imperative to prioritize meaning over form in instruction to foster genuinely confident and competent speakers.

**Keywords:** oral speaking skills, communicative approach

### Introduction

In the contemporary global landscape, English and other foreign languages function not merely as academic subjects, but as essential tools for participation in international communication, professional environments, and intercultural exchange. Therefore, the ability to speak a language fluently and confidently is increasingly recognized as a critical indicator of successful language acquisition. Yet, despite decades of research supporting communicative pedagogy, many classroom practices remain rooted in structuralist traditions that emphasize form over function. Students are often evaluated on their ability to produce grammatically correct sentences in controlled environments, while spontaneous oral expression—which involves uncertainty, improvisation, and authentic communicative intent—receives significantly less instructional attention.

This discrepancy between knowledge about language and the ability to use language continues to be a central challenge in second and foreign language education. The Communicative Approach (CA) emerged in response to this pedagogical misalignment. CA re-frames language as a *social practice*, prioritizing the meaningful exchange of ideas, negotiation of meaning, and co-construction of understanding between speakers. It acknowledges that communication is inherently contextual: effective speakers adapt their language according to audience, purpose, cultural norms, and situational expectations.

Moreover, CA aligns with sociocultural theories of language development, particularly those of Vygotsky, which propose that knowledge is constructed collaboratively and interactionally. Language learning thus becomes not an internal cognitive event alone, but a socially situated process in which the learner actively participates. In a communicatively oriented classroom, learners engage in purposeful interaction, respond to

real communicative needs, and gradually build both confidence and competence.

To meet the oral communication demands of the 21st century, instructional practices must evolve from transmission-based models to approaches that nurture learner agency, risk-taking, and creative expression. CA offers a pedagogical framework capable of transforming the classroom into an interactive communicative environment, where students not only learn the language system but experience what it means to *live* and *think through* the language.

### The Communicative Approach and Oral Expression

Oral communication represents the most dynamic and immediate mode of language expression, as it requires real-time cognitive processing, linguistic flexibility, and sensitivity to contextual and interactional cues. Unlike written communication, where the speaker has time to plan, revise, and refine expression, spoken language unfolds spontaneously, necessitating rapid decision-making and continuous adjustment. For language learners, this means simultaneously balancing fluency and accuracy while also managing affective factors such as confidence, anxiety, motivation, and self-perception as language users. These emotional dimensions often shape students' willingness to speak more strongly than their linguistic knowledge itself.

Extensive research has shown that oral proficiency does not develop solely through grammatical instruction or controlled practice. While explicit knowledge of linguistic rules contributes to accuracy, it does not, by itself, lead to communicative confidence. When language instruction focuses excessively on error correction and rule memorization, learners may internalize what scholars term "learned silence"—a condition in which they understand language but refrain from speaking due to fear of making mistakes or violating

grammatical expectations. The result is passive competence rather than active communicative ability.

The Communicative Approach (CA) offers a deliberate response to this challenge by shifting the instructional focus from *form* to *function*. One of its core principles asserts that the primary purpose of language is to convey meaning. Therefore, effective language learning environments must prioritize meaningful interaction, authentic communicative intent, and negotiation of meaning. As highlighted by Méndez Vergaray et al. (2021), the strongest gains in oral competence occur when learners engage in realistic communication

tasks that require them to generate novel language under conditions resembling real-life social interaction.

Within CA-based classrooms, instruction evolves from mechanical drills to interactive, purpose-driven communication. Students are not merely passive recipients of language input; rather, they actively co-construct meaning with peers. Tasks are designed to require authentic linguistic exchange, such as information sharing, collaborative problem-solving, decision-making, and perspective negotiation. Through these activities, learners develop the three foundational dimensions of oral communicative proficiency:

Table 1.

Core Components of Oral Communicative Proficiency

| <i>Component</i>         | <i>Description</i>                                                                                        |
|--------------------------|-----------------------------------------------------------------------------------------------------------|
| Fluency                  | The ability to speak smoothly and spontaneously without excessive hesitation.                             |
| Accuracy                 | The correct use of grammar, vocabulary, and pronunciation to support clarity.                             |
| Interactional Competence | The ability to manage conversational flow, respond appropriately, and maintain communication effectively. |

A distinctive strength of CA lies in its task design principles. Effective communicative tasks must incorporate:

An information gap — ensuring speech is necessary to complete the task.

Choice and autonomy — allowing learners to decide what and how to express.

A non-linguistic outcome — where the measure of success is accomplishing the task (e.g., planning an event, solving a riddle), not producing grammatically perfect sentences.

When these conditions are present, learners focus not on avoiding mistakes but on expressing meaning. Errors become natural, informative steps in the developmental process, rather than failures to be immediately corrected. This promotes a low-affective-filter environment, where learners feel safe to take communicative risks, experiment with language, and gradually strengthen their ability to speak with confidence.

Furthermore, oral communication skills developed through CA carry significance beyond the language classroom. Students who can present ideas clearly, negotiate viewpoints respectfully, and collaborate verbally are better positioned for academic, professional, and civic participation in increasingly multilingual and multicultural societies. Thus, fostering oral communication through the Communicative Approach is not merely a linguistic task—it is a social, cognitive, and cultural necessity for preparing globally competent learners.

Central to the success of CA is the concept of student engagement and the utilization of student-centered approaches (Kuvandykova, 2023). When students are placed at the center of the learning process, their motivation and participation are significantly enhanced. This shift is critical because oral production demands a lower affective filter; a learner who feels safe, valued, and intrinsically motivated is more likely to engage in the risky, public act of speaking.

Pedagogically, this is achieved through active methodologies such as collaborative learning and problem-solving activities. These tasks demand reciprocal

communication, where success hinges not merely on correct grammar, but on successful message conveyance. Consequently, the learner is naturally driven to prioritize communicative effectiveness, thereby honing their oral skills in an organic, functional manner.

The efficacy of the Communicative Approach is maximized when it is integrated with specific, dynamic pedagogical strategies that transcend the boundaries of the language arts classroom.

### **Project-Based Learning (PBL) and Creative Production**

Project-Based Learning (PBL) offers a robust framework for applying CA principles. As research indicates, the project method has a positive impact on the development of creativity of students (Alimanova et al., 2024). In the context of oral skills, a communication-focused project—such as preparing and delivering a public presentation, conducting an interview series, or staging a debate—requires sustained, complex, and purposeful oral output.

PBL provides a realistic context where language is a tool for achieving a tangible outcome. The sustained nature of the work requires students to engage in multiple drafts, peer critique, and ultimately, a final presentation, providing ample, high-stakes opportunities for refining fluency and articulation. This process moves beyond single-sentence drills to the development of coherent, extended discourse.

In a globalized world, oral proficiency must include the ability to navigate diverse cultural contexts. The integration of cultural diversity and cultural responsiveness into EFL teaching strategies significantly enhances both the relevance and the effectiveness of language instruction (Nurgalynova & Salkam, 2023; Kuvandykova, 2023).

When CA tasks involve discussing diverse literary texts, analyzing global media, or role-playing intercultural interactions, students develop essential intercultural communication skills. This goes beyond simple linguistic accuracy; it involves understanding register, non-verbal cues, and the socio-pragmatic function of language. By incorporating local cultural contexts into

instruction, as highlighted by educators in Kazakhstan, the learning becomes more relevant, increasing student motivation to articulate complex ideas and bridge cultural gaps through spoken word. This dual focus—linguistic and cultural—is essential for graduating truly competent global communicators.

The success of CA is heavily reliant on the transition of the teacher's role from authoritative knowledge dispenser to that of a facilitator and guide. The teacher's primary task is to manage the flow of communication, establish motivating contexts, and intervene strategically. The teacher must model effective communication and create a non-threatening atmosphere where students feel comfortable taking risks with the language.

Crucially, feedback in a CA setting must be handled judiciously. During fluency-focused activities (like debates or role-plays), error correction is often delayed or indirect, primarily targeting errors that impede meaning. This minimizes interruption and maintains the flow of the activity. This principle contrasts sharply with accuracy-focused work where direct correction and metalinguistic explanation are appropriate. By prioritizing comprehensible communication, the teacher reinforces the core CA tenet that communication precedes correction.

The evidence overwhelmingly supports the position that the Communicative Approach is not merely an effective method, but the pedagogical imperative for the cultivation of robust oral speaking skills in the modern school. By prioritizing interaction and meaning negotiation over rote memorization and grammatical analysis, CA shifts the locus of control to the student, fostering the essential confidence and fluency required for real-world application.

The effective praxis of CA is found in integrated methodologies:

**Student-Centered Tasks:** Cultivate motivation by granting ownership over the learning process.

**Collaborative Learning:** Provides a low-stakes environment for rapid, real-time negotiation and fluency practice.

**Project-Based Learning:** Demands sustained, complex oral output, moving learners into extended discourse.

**Cultural Responsiveness:** Ensures that the language learned is functionally appropriate for diverse global and local interactions.

While challenges remain—particularly in teacher training to fully embrace these student-centric methodologies and address diverse student needs—the transition is not purely procedural. Significant institutional obstacles persist, notably the tension between CA's fluency-first approach and traditional, high-stakes assessment systems that overwhelmingly reward grammatical accuracy. Furthermore, rigid, content-heavy curricula often limit the time required for open-ended, communication-rich activities like PBL. Overcoming these requires systemic alignment, professional development focused on communicative task design, and the adoption of performance-based assessment rubrics that

quantify the critical elements of fluency and interactional competence. The ultimate goal is to produce learners who do not merely *know* English, but who can function powerfully and creatively through oral expression. Future research should quantitatively assess the long-term impact of specific PBL and intercultural CA models on the retention and transferability of advanced oral skills.

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## INTEGRATED PEDAGOGICAL APPROACHES TO CULTIVATING LINGUISTIC CREATIVITY AMONG SCHOOL LEARNERS

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### Abstract

This article examines comprehensive pedagogical approaches to fostering students' linguistic creativity in the context of school language education, with a specific focus on Kazakh and English language classrooms. Linguistic creativity is considered a core component for shaping communicative competence, critical thinking abilities, and learner autonomy. The study synthesizes international academic insights and Kazakhstan's national educational priorities to outline effective strategies such as creative writing, genre-based interpretation, linguistic games, role-play, visual-literary integration, digital media applications, and project-based learning. Inclusive practices that support diverse learners' needs are emphasized. Challenges—including curriculum rigidity, teacher preparation gaps, and limited technological access—are discussed, followed by recommendations for policy enhancement, teacher professional development, and collaborative resource-sharing. Cultivating linguistic creativity is presented not merely as an enrichment activity but as a key dimension of holistic education that enables students to construct meaning, express individuality, and participate competently in the multilingual and multicultural realities of the 21st century.

**Keywords:** linguistic creativity; communicative competence; multilingual education; creative pedagogy; digital tools; Kazakh language classroom.

### Introduction

The rapid development of global information and communication technologies has reshaped educational priorities, shifting the focus from mastering linguistic accuracy alone to cultivating genuine linguistic creativity. In modern society, it is no longer sufficient for learners to simply acquire grammatical rules and vocabulary; they must also be able to manipulate language flexibly, generate original expressions, and use linguistic resources effectively in varied communicative situations. Linguistic creativity, therefore, is not a supplementary or optional skill but a fundamental requirement for innovation, critical thinking, and active participation in a complex and culturally diverse world.

However, traditional pedagogical models often compartmentalize language teaching, separating grammar, literature, and composition into isolated instructional units. This fragmentation can impede the natural, integrative process of creative language use, limiting students' ability to perceive language as a dynamic, meaning-making system. As a result, contemporary educational research increasingly emphasizes integrated pedagogical approaches that transcend disciplinary boundaries and situate language learning within authentic, meaningful, and cognitively rich contexts.

Within the educational landscape of Kazakhstan, these shifts align closely with national strategic priorities. Modern schooling is tasked with harmoniously synthesizing global cultural knowledge and national spiritual values, fostering learners who are culturally grounded, intellectually developed, and capable of continuous self-directed learning. The State Curriculum identifies communicative competence, critical thinking, and cultural identity as core learning outcomes, while the trilingual education policy—promoting proficiency in Kazakh, Russian, and English—creates a

naturally multilingual environment conducive to linguistic creativity. Exposure to multiple linguistic systems allows students to interpret, compare, and creatively transfer expressive forms across languages.

Language subjects, particularly Kazakh and English, provide extensive opportunities for fostering creativity through literary interpretation, dialogic interaction, narrative composition, and reflective writing. Drawing on Vygotsky's sociocultural theory, creativity is understood not as an innate talent possessed by a select few, but as a developmental process cultivated through guided practice, social collaboration, and meaningful engagement with language. International scholarship further supports this: Hofweber and Graham (2017) highlight the value of literary texts in stimulating linguistic innovation; Cross (2012) demonstrates the pedagogical significance of everyday creativity in CLIL contexts; Jaborova (2021) shows that structured creative tasks enhance expressive originality; Kazachkova and Dorokhova (2019) illustrate the role of collaborative language games in developing verbal fluency; and Kiyashko (2008) emphasizes linguistic play as a catalyst for inventive language use.

Moreover, recent educational reforms in Kazakhstan place strong emphasis on developing soft skills such as collaboration, problem-solving, adaptability, and communicative competence—all of which are directly linked to linguistic creativity. Thus, integrated pedagogical approaches that combine language instruction with broader cognitive, cultural, and expressive development are not only timely but essential for shaping learners who are linguistically agile, culturally literate, and capable of creative self-expression in the 21st century.

Effective creativity-oriented language teaching involves purposeful selection of instructional tasks and multimodal learning experiences:

*Creative narrative continuation:* Students are provided with the opening of a story or dialogue and encouraged to craft original endings, promoting narrative reasoning and imagination.

*Transformative writing:* Producing fairy-tale retellings, diary entries, character letters, or reflective mini-essays supports emotional awareness and voice formation.

*Linguistic games:* Wordplay activities—anagrams, metaphor construction, syntactic reconstructions—strengthen linguistic intuition and divergent thinking.

*Role-play and dramatization:* Performing dialogues or simulating real-world communication situations enhances spontaneity and interactional confidence.

*Visual-verbal integration:* Drawing characters, creating storyboards, and combining imagery with textual description support comprehension and multimodal expression.

*Project-based learning:* Creating storybooks, podcasts, or video narratives situates language use in authentic communicative contexts and advances digital literacy.

*Extracurricular creative involvement:* Poetry circles, debate clubs, and writing competitions extend linguistic creativity beyond classroom boundaries.

In Kazakh language lessons, elements of creativity are already embedded—for instance, composing short poems, constructing dialogues from literary texts, summarizing and transforming folk narratives, and reformulating proverbs into micro-stories. Teacher guidance involves differentiation and personalization—assigning varied modes of creative output depending on students' strengths (e.g., visual artistic students may illustrate, verbally strong students may narrate).

Digital platforms such as Canva, Padlet, and Flipgrid enhance opportunities for multimodal expression, collaborative creativity, and self-presentation.

Despite pedagogical advantages, several barriers limit systematic implementation:

Standardized assessment pressures reduce time for creative exploration.

Insufficient teacher training in creative methodologies and digital tool integration.

Resource constraints in rural schools, including class size and limited technology access.

Addressing these issues requires:

Comprehensive teacher professional development programs focused on creative pedagogy and ICT integration.

Curriculum adjustments to allow flexible task-based and project-based learning.

School collaboration networks aimed at sharing resources, materials, and methodological innovations.

### Conclusion

Linguistic creativity in language education is not an optional supplement but a foundational pedagogical priority. It cultivates learners who think independently, communicate expressively, and engage with cultural narratives in meaningful ways. A linguistically creative student not only learns language but lives through language—constructing meanings, expressing identity, and participating actively in social and cultural life. The development of linguistic creativity thus plays a crucial role in preparing future citizens who are articulate, adaptive, empathetic, and culturally aware.

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# PSYCHOLOGICAL SCIENCES

## PSYCHOSOCIAL DYNAMICS OF YOUTH

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### Abstract

Adolescence is an important stage in the psychological, social and biological development of a person. During this age period, the main qualities of personality are formed, self-awareness, self-consciousness, self-esteem and moral qualities develop. Young people's social relationships, friendships and inter-gender interactions are strengthened, and social activity increases. Independent decision-making and the desire to participate in various areas of life are more pronounced during this period. The management of emotions, ideal love and sexual maturation processes are also of particular importance during adolescence. Parents' adherence to the principles of freedom, support and consultation in their relationships with young people contributes to the correct formation of personality. The article also emphasizes the gender differences in the socio-psychological development of young people and their attitudes to values in modern times.

**Keywords:** adolescence, personality development, self-awareness, self-consciousness, gender relations, ideal love, parental relationship

A person goes through different age periods in his development, and each period has a certain impact on the development of personality. The youth of a person's life is the period of physical maturity, the rapid development of his self-awareness, intellect, the formation of his unique high qualities, worldview, choosing a profession and starting an old age. The youth age in its development usually goes through two stages: the first stage is called early youth (15-17 years old), and the second stage is called mature youth (18-25 years old).

Early youth is a period when the basic qualities of personality are formed and social activity increases. He gains citizenship and the right to be elected. At this age, a number of new qualities emerge: self-awareness, self-esteem and self-consciousness develop; moral views and beliefs, worldviews are formed; the tendency to independence, self-affirmation and self-education strengthens, etc.

"During adolescence, a number of socio-psychological qualities of personality, especially idealism, moral purity, spiritual richness, activity, being principled in work, consistency of words and deeds, clarity of purpose, etc., become more noticeable and rapidly form. At the same time, they engage in the struggle for ideas and beliefs, and defend their worldviews" [4, p.189].

Young people have a strong need for reflection on their feelings and thoughts, for self-awareness. Questions such as "Who am I?", "What am I capable of?", "What is the meaning of life?" make them think. At this age, interest in moral issues also increases. Speaking the truth, being principled, and honest are characteristic of young people. They value honesty, humility, hard work, simplicity, and kindness in people more highly. Criticism and self-criticism are characteristic of young people.

Youth is a period of searching for vital innovations and adventures. The end of the youth period means the existence of a generation fully prepared for society. For this reason, parents who want to correct any mistakes

in the behavior of young people should do the process indirectly, not directly, and prefer a friendly, companionship position. In order for young people to understand their personal needs and feelings, to be responsible for the steps they take, and to make important life decisions independently, parents should accept that they are growing up, give their children who have entered the youth period freedom, and try to help them as advisors, not as executors, in overcoming the difficulties they encounter. It is not necessary to think that if young people are given freedom, their attachment to the family will decrease, on the contrary, the value of the family will be recognized more. Because, the feeling of freedom and making independent decisions naturally cause certain difficulties for young people, and as each difficulty is experienced, the value of the parents who solve these difficulties on their own is also recognized and their hard work is also appreciated.

"Young people develop and are formed under the influence of biological, psychological, psychosexual and sociological factors. Although biological development is completed in the body during youth, psychological (cognitive processes, worldview, beliefs, will and moral qualities, feelings, etc.), psychosexual (formation of interest in the opposite sex, tendencies, needs, etc.), sociological (integration into social relations, formation of social status and position, etc.) development becomes more active and improved. Among these, socio-psychological factors occupy a special place in the formation of young people as a personality. Therefore, youth can be noted as a socio-psychological phenomenon" [2, p.341].

"A number of psychologists have called the early youth period by different names. For example, Russian psychologist L.S. Vygotsky characterized this age stage as the puberty age period, and D.B. Elkonin as the period of older adolescence. L.I. Bojovich believed that the most important feature of mental development during the older school age period is the realization of self-determination, opportunities and aspirations in

human society. During the older school age period, the contradiction between the mental capabilities of young people and the increasing demands of the elderly and society becomes the driving force of mental development" [1, p.307].

The youth period is considered a continuation of education, a period of improvement of personal qualities formed up to this time. This period is the culmination of the formation of female and male characteristics, the foundation of which has been laid since childhood, and is the period when the foundation of a worldview specific to women and men for later life is laid. During this period, young people already make their independent choices based on stereotypes and standards about femininity and masculinity and demonstrate behavior in accordance with their gender in mutual relations. Young people who have graduated from high school and earned the title of student try to master existing knowledge related to socio-political, scientific, economic, cultural, religious, etc. fields. The set of these components serves to improve a person's worldview.

During the youth period, the process of mastering the secrets of the chosen professions, the formation of independent ideas in accordance with the needs of life and the struggle for the realization of these ideas, neutrality or choice between the social, real and ideal self in order to gain appropriate respect in society, the prominence of the differential sexual behavior characteristic of women and men, and the change of the structure of the personality in accordance with social relations take place. The joining of young boys and girls to existing relationships leads to the loss of character traits preserved from childhood, and the emergence of relationships similar to the relationships existing between adults, both internally and externally. If the basis of these relationships is mutual respect and equality, the subsequent process leads to a positive direction of the social lifestyle and inter-gender relations.

The establishment of youth friendships and attempts to enter into closer interpersonal relationships with people occur in girls 1.5-2 years earlier than in boys. This is due to the somewhat earlier onset of puberty in girls, and this need is felt in them much earlier than in boys. In late adolescence and early adulthood, they tend to be friends with representatives of the opposite sex. Girls, as a rule (unlike boys), attach more importance to building interpersonal relationships with people of the same age group and are more emotional.

During adolescence, the mechanism for managing emotions becomes active, but emotionality is often observed in young people's behavior in response to the difficulties of adapting to numerous social innovations.

One of the biggest changes in the emotional world of young people is the feeling of love. Psychologists associate it with sexual maturation. In terms of its content, it differs significantly from the sympathy of younger schoolchildren and the first love of adolescents. While in adolescents the feeling of love, which arises on the basis of sympathy for the opposite sex, has a superficial, attractive character, in early

youth this feeling is distinguished by its depth, strength and true love. Since sexual maturation is completed at this age, it is characterized by clearly expressed sexual overtones.

During this period, young people's search for the ideal lover in their impressions in real life and some young men or women, even if they start a family, are driven to spiritual loneliness due to the failure of this search. Young people who have experienced the conflicting period of adolescence often understand the correctness of parental advice better during this period, believe that it will be beneficial for them, and their trust in parents and teachers increases. Representatives of the younger generation must be able to choose between good and evil while still under parental care. The closer the parents or people who will support them are to those they protect, the less danger awaits that person.

Youth is a period of education and upbringing in which a person has the authority to form the necessary qualities in himself by passing ethical and aesthetic moral rules through his mental framework and to implement them without accepting any interference. Youth is the period of laying the foundation for determining the social status of the individual, the enrichment of rights and duties, the beginning of independent activity and social activism.

"The processes that accelerate during adolescence include cognitive processes, voluntary regulation of emotion, socialization, assimilation of social rules and adherence to them, self-affirmation, improvement of worldview, psychological development, political and critical thinking, learning of legal and social rules, exercise of citizenship rights, manifestation of gender-specific characteristics in behavior, the need to be loved and chosen, acquisition of sexual culture, inclination to start a family, formation of an individual lifestyle, ambition, struggle for the realization of dreams, acquisition of the secrets of the necessary qualifications to occupy a worthy place in the business environment, integration into the labor market, independence in personal and business activities" [3, p.141].

The period of youth is an important stage in the development of the growing generation - the completion of the transition to adulthood, the formation of self-awareness, and the formation of a socio-psychological being. The formation of social qualities accelerates during the youth period. As young people develop, they fully understand their goals and strive to achieve them, which has an impact on the perfection of their personality.

During adolescence, personality is formed as a biosocial-psychological entity, where enterprising, principled, responsible forms of behavior are formed; the young person becomes ready to perform complex intellectual operations, his special abilities develop rapidly. Communication and the creation of friendship groups of young people appear as their natural, socio-psychological need. At this age, the main educational aspect of the communication process is more noticeable, they strive to unite with their peers, create friendship groups, and of course, in this process, interpersonal relationships, friendship, and comradeship are formed in young people.

Thanks to the development of self-awareness, which is an important psychological phenomenon in adolescence, the young person begins to better understand his personality, abilities, moral qualities, himself, evaluates his place and position in the group, is able to see his positive and negative aspects, then the concept of the self becomes more stable, self-control, self-determination are formed. Young people are assessed by those around them (relatives, neighbors, parents) as old people in terms of both physical and mental qualities, the feeling and tendency of old age in them is combined with the act of self-affirmation, and they try to stand out from the elderly, to show themselves in a more independent, original way. During this period, in addition to understanding and evaluating their psychological qualities, the content of their self-consciousness, their self-image changes: boys and girls become excessively obsessed with themselves, appreciate their external beauty, a small physical defect worries them, and even if boys are very fat or short, they consider it a defect for themselves. Young people use physiognomic masks to hide their appearance flaws, even certain deformities. Young people explain their personal moral qualities, as well as their behavior, manners and attitude, their external beauty, their mind from a socio-social perspective and evaluate them as a whole, and they also understand the values of outsiders. However, when older schoolchildren do not evaluate themselves realistically, they are at risk of egocentrism. Young people's self-awareness depends largely on their social background, level of education, personal characteristics, the people around them, and the copies of the works they read. Young people make certain judgments about themselves based on these factors. The self-esteem that boys and girls give to themselves during adolescence and the evaluation of others form and develop a sense of personal dignity and self-respect in them. The main feature characterizing the self-esteem of young people is the understanding of sexual characteristics and qualities. The social activity and life position of young people have strategic importance and are characterized by orientation towards the future. Young people are not just interested in domestic and international events, they think about their short and long-term plans. Young people, while understanding the outside world, evaluate it, express their attitude to the world, and defend their own particular views, beliefs, opinions, and attitudes.

The correct implementation of gender roles is one of the essential conditions for the formation of normal relationships. Because the success of both the family and the business sphere depends on the correct distribution and implementation of these roles. The interdependence between representatives of the opposite sex inevitably leads to the establishment of healthy relationships. The closer people get to know each other, the more independent and liberated their relationships become. Mutual need makes representatives of the opposite sex observe each other's positive or negative characteristics. Both women and men are looking for a real image of a person who is in harmony with their nature in order to find their life partner. If this finding coincides with the image

existing in the dream, then processes such as supporting, helping, and understanding each other will continue until the end of their lives. Therefore, such a process also has a positive effect on behavior. Thus, the imagination of ideal female-male images plays the role of a moral regulator for the behavior of young boys and girls, characterizing the determination of their relationships with their peers of the opposite sex.

Unfortunately, often when searching for the imaginary image of the desired partner for family life, the matching of external similarity overshadows the verification of the matching process of spiritual similarity. When family life is established, the problems associated with the lack of spiritual compatibility outweigh the satisfaction of the life partner in terms of external appearance. This leads to an increase in the number of unsuccessful families.

Boys are more concerned with accuracy in any matter. Girls, on the other hand, are more prone to romance, approach life through an emotional prism, are more prone to emotional reactions, and are more sensitive.

Since adolescence is considered the most popular period for boys to choose girls for marriage, girls strive to succeed in interpersonal relationships, attract the attention of others, and be liked. Young girls who like to be the center of attention, as well as trying to be liked by demonstrating qualities such as politeness, gentleness, and good-naturedness, are more sociable (this process also has a certain connection with biological development: girls speak faster than boys, walk faster, and the early development and fluency of girls' oral speech, the natural ability to follow the speech of others, their deep interest in people, and their deep, close communication with their mothers ensure the development of their speech organs and sociability). In young boys, the reason why the level of courage, organization, awareness, collectivism, solidarity and other volitional characteristics is more developed than other characteristics is explained by the high physiological capabilities of boys, for example: the ability to defend the interests of their friends through force has a positive effect on the formation of qualities such as collectivism, courage, ambition, organization. Therefore, although young boys and girls have similar general characteristics in their personalities, their differences due to their gender also attract attention: Young boys have higher levels of willpower qualities such as organization, determination, persistence, hard work, courage, initiative, solidarity, and keeping one's word compared to other characteristics, while young girls have higher levels of moral qualities such as responsibility, sociability, and shyness, and lower levels of willpower qualities such as organization, determination, persistence, hard work, courage, initiative, and keeping one's word.

As young people's ability to think independently improves, they give a more objective assessment of their parents' personal qualities. Therefore, it should be taken for granted that a young person, despite loving and respecting their parents, does not choose their parents as a role model for themselves due to their personal qualities. In such a case, instead of being

offended, the parent should take another look at their own personal qualities. Parents should realize that if children were more inclined to observe and imitate until adolescence, they already demonstrate and apply what they have acquired during adolescence. If a parent does not like something in the behavior of their young child, they should correctly determine what the mistakes made are in time and analyze in detail the ways that will serve to eliminate this problem. Because, direct educational influences during this period can cause conflicts.

The rules that help parents establish normal relationships with their adolescent children include: respecting the child's personal qualities; creating conditions for self-affirmation; providing freedom of thought; consulting with the child in making family decisions; setting a personal example in guiding the process of forming the qualities necessary for adulthood; providing freedom of communication and activity; providing assistance in determining an individual lifestyle; showing confidence in the young person's ambition; approaching failures with support, not criticism; not interfering in the young person's intimate life; resolving any misunderstandings not through conflict, but through ways based on mutual understanding; accepting the young person's independence.

Every person who thinks about his future works out methods of transferring his life experience, which he has improved over time, to the younger generation and fights to prevent the mistakes made from being repeated again. The successful result of the struggle is manifested in the formation of a high-level personality for society. If any era supported an authoritarian position in upbringing, now violent upbringing methods are categorically not accepted. The new era changes the positive and negative features of the past in

accordance with current needs. This process also has an analogous effect on the dynamics of the development of the personality of the younger generation: young people's views on values, lifestyles, desires, deeds, etc. change. If in the past, the majority of young people preferred romance, today's young people live more realistically and act in accordance with democratic principles. In this context, the acquisition of universal moral values, comprehensive provision of human rights, and the creation of sound material and spiritual foundations in the formation of the younger generation are considered to be the most urgent problems of the modern era.

The life process can also be viewed as a process of confrontation, where conflict-causing factors, unfavorable conditions, and obstacles confront a person and either destroy or educate him in this confrontation. From this perspective, the correct approach of parents to their young children: their readiness to help in any difficulty, their efforts to make their lives more interesting, and their efforts to educate their moral and volitional qualities at the appropriate level ensure the problem-free youth of the growing generation and the formation of normal personalities of the people who will form the composition of society.

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# SOCIAL SCIENCES

## CONTEMPORARY ETHNIC ENTREPRENEURSHIP AND BUSINESS IN THE LIGHT OF SIMILARITIES AND DIFFERENCES

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## СОВРЕМЕННОЕ ЭТНИЧЕСКОЕ ПРЕДПРИНИМАТЕЛЬСТВО И БИЗНЕС В РАКУРСЕ СХОДСТВ И РАЗЛИЧИЙ

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### Abstract

This article provides a comparative analysis of the paradigm and discourse surrounding contemporary ethnic entrepreneurship and ethnic business. The lack of clear distinctions between the concepts of entrepreneurship and business, identified in numerous foreign and Russian-language publications, including academic ones, and discussions about the differences between business and entrepreneurship, prompted this case study. Through a historiographic study of English- and Russian-language academic publications, the articles reveal a range of interrelated aspects, including the diversity of definitions of ethnic entrepreneurship; differences in the characteristics of entrepreneurship and business; the key characteristics and components of ethnic entrepreneurship; and the characteristics of ethnic entrepreneurship among Koreans abroad.

### Аннотация

Статья посвящена сравнительному анализу парадигмы и дискурса современного этнического предпринимательства и этнического бизнеса. Отсутствие чётких разграничений в понимании понятий предпринимательства и бизнеса, выявленное во зарубежных и русскоязычных многих публикациях, в том числе академических и дискуссии о различиях бизнеса и предпринимательства стали причинами осуществлённого case study. В результате проведённого историографического исследования англо- и русскоязычных научных публикаций в статьях раскрывается совокупность таких взаимосвязанных аспектов как: многообразие определений этнического предпринимательства; различия в характеристиках предпринимательства и бизнеса; основные признаки и компоненты этнического предпринимательства и особенности этнического предпринимательства зарубежных корейцев.

**Keywords:** immigration, diaspora, ethnic networks, entrepreneurship, business, similarities, differences

**Ключевые слова:** иммиграция, диаспора, этнические сети, предпринимательство, бизнес, сходства, различия

### Введение

Рубеж XX и XXI веков ознаменован сложными процессами бурным ростом предпринимательства, так как именно в этот период в постсоветских государствах (включая Россию и страны Центральной Азии), а также в бывших странах-сателлитах Советского Союза в Восточной Европе, Азии и Африке сформировались политические и правовые основания для рыночных отношений, ключевым элементом которых стало предпринимательство. Этот феномен стал объектом исследования многих учёных: экономистов, социологов, этнографов и историков. В последние десятилетия проявился растущий интерес к этническому предпринимательству, связанному, прежде всего, с трансграничными миграциями, охватившими миллионы людей и многие десятки стран мира. На пороге смены веков и миллениума азиатский континент превратился не только в арену ведущих игроков мировой экономики: Китая, Японии, Южной Кореи и других азиатских «драконов», но и транснационального обмена трудовыми ресурсами. При этом, некоторые страны, которые в недавнем прошлом относились к донорам рабочей силы, стали активными и быстро

растущими реципиентами иностранных рабочих. К примеру, из Южной Кореи, в 1970-80-х года сотни тысяч человек мигрировали в другие страны в поисках новых возможностей, с целью достижения успеха в бизнесе и обеспечения лучшей жизни для своих детей. Теперь Южная Корея сама стала принимать сотни тысяч трудовых иммигрантов из стран Юго-Восточной Азии, Китая, Монголии, России и стран Центральной Азии, которые восполнили дефицит рабочих рук и стали заниматься 3D job – difficult, dirty, dangerous, то есть трудным, грязным и опасным трудом.

В постсоветских государствах Центральной Азии, вступивших на путь укрепления своего национального суверенитета на основе титульных наций, этнические меньшинства оказались перед дилеммой редуцированной конкуренции в секторе государственной экономики и крупном бизнесе или поиска своих ниш в сфере предпринимательства. Некоторым представителям этнических меньшинств (не титульных наций) удалось, в силу ряда обстоятельств, достичь вершин бизнес-Олимпа, однако большинство предпринимателей из этой среды

сумели занять ниши преимущественно в малом бизнесе. В среднем звене бизнеса их доля значительно ниже.

### Сходства и различия в современном предпринимательстве

Что такое предпринимательство и чем оно отличается от бизнеса? Предпринимательство – сложное понятие, определение которого во многом зависит от фокуса проводимого исследования, поэтому, чтобы понять его понятийную суть, следует перечислить его характерные черты. Исследователи отмечают, что к таковым относятся: инновации, креативность, обращение к нереализованным возможностям, лидерство, инициативность, нацеленность на получение прибыли, оперативность в принятии решений, готовность к риску и принятию ответственности со стороны главного действующего лица – предпринимателя. Успешное предпринимательство перерастает в бизнес, а неудавшееся сменяется новой предпринимательской попыткой.

Во многих публикациях, в том числе академических, чётких разграничений в понимании понятий предпринимательства и бизнеса. В русском языке слова «предпринимательство» и «бизнес» имеют более высокую степень синонимичности, чем в английском языке. Если обратиться к этимологии слов, то на английском «business» означает дело, предприятие, деятельность для получения прибыли. Слово «entrepreneurship» происходит от глагола в старофранцузском «entreprendre», что означает «предпринимать». Предпринимательство означает деятельность по созданию нового легального вида бизнеса. Под бизнесом понимается организованная, институализированная, стабильная экономическая деятельность, направленная на получение дохода, масштабирование производства, оказание услуг и удовлетворение потребительского спроса. Предпринимательство – деятельность по

поиску новых идей и созданию нового вида бизнеса. Ключевая роль принадлежит предпринимателю, для которого свойственны лидерские качества, инициативность, готовность идти на риск, умение оперативно находить эффективные решения. Бизнес – это про извлечение прибыли, а предпринимательство – это креативность в создании нового вида бизнеса. Таким образом, любой предприниматель в случае успешной реализации идеи может стать бизнесменом, но не каждый бизнесмен является успешным предпринимателем.

Понятие «предприниматель» (entrepreneur) впервые использовал в начале 18-ого века Ричард Кантильон – один из основателей современной экономической теории. Этим словом он назвал человека с неопределёнными доходами, который приобретает товары по одной цене, а продаёт их по другой. Р. Кантильон, которого называют французским экономистом, родился ирландцем, успешно занимался коммерцией в Лондоне, а затем стал известным банкиром во Франции. В 1755 году через 20 лет после его смерти во Франции был опубликован главный труд «Опыт о природе коммерции: общие опросы», прославивший его как учёного-экономиста. (1). Безусловно, что в 18-веке не существовало бизнеса в современном понимании, не было собирательного понятия «бизнесмен», а были купцы, торговцы, банкиры, фабриканты и заводчики, однако такие слова как делец, а чуть позже – предприниматель использовались на европейском континенте в обиходной речи.

Дискуссии о различиях бизнеса и предпринимательства привели к мысли о составлении таблицы, в которой наглядно приводятся результаты сравнительного анализа различий между ними по таким основным параметрам как: цели, функций руководителя предприятия; организационной структуре, креативности компании; оперативности и гибкости принятия решения и роста производства или денежных оборотов.

Таблица 1.

Различия в характеристиках предпринимательства и бизнеса

| Критерии                  | Бизнес                                                                                       | Предпринимательство                                                                                            |
|---------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Дефиниция                 | Коммерческая, производственная или сервисная деятельность, направленная на получение прибыли | Генерация инновационной бизнес-идеи с целью запуска коммерческой, производственной, сервисной деятельности     |
| Цель                      | Получение устойчивой и растущей прибыли путём предоставления товаров или услуг потребителям  | Удовлетворение запросов потребителей, внедрение инноваций, трансформация предпринимательства в бизнес          |
| Роль руководителя         | Глава компании - первый руководитель, один из топ-менеджеров                                 | Предприниматель - ключевая фигура                                                                              |
| Организационная структура | Структурированный хозяйствующий субъект со штатным расписанием                               | Формирующийся штат менеджеров и сотрудников                                                                    |
| Риск                      | Минимизированный опытом деятельности риск, страхование бизнеса                               | Высокая степень риска, готовность к провалу бизнес-идеи и запуска нового старта                                |
| Креативность              | Стабильность в развитии и рост прибыли, не обязательно связанные с радикальными инновациями  | Предпринимательство основано на креативности, на генерации нетривиальной бизнес-идеи                           |
| Оперативность и гибкость  | Бизнес может продолжаться инерционно, опираясь на устоявшиеся системы и процессы             | Предпринимательство требует оперативного принятия решения, тактической гибкости, готовности к резким переменам |



|             |                                                                          |                                                                                      |
|-------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Рост</b> | Долгосрочное планирование роста показателей бизнеса и увеличение прибыли | Краткосрочные эксперименты с ожидаемыми (предполагаемыми) максимальными результатами |
|-------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------|

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Предприниматели сосредоточены на преодолении проблем, создании новых предприятий, личной ответственности, инициативы, принятии быстрых решений и ожидают признания достигнутых успехов. Ими движут не только экономические, но и психологические мотивы, такие как стремление к инновациям и созданию новых продуктов. Предприниматели обладают многими теми же чертами характера, что и бизнесмены, руководители предприятий и компаний. Дэвид Макклелланд, выдающийся американский психолог, получивший широкую известность благодаря своим трудам о факторах, побуждающих людей к успеху, утверждает, что «предпринимателя в первую очередь мотивирует непреодолимая потребность в достижениях, и у него есть сильное стремление к созиданию». (2) Предприниматель постоянно придумывает something new-something better, то есть – что-то новое, что-то лучшее.

Понятия «предпринимательство» и «бизнес» (в особенности, когда речь идёт о малом и среднем бизнесе - МСБ) часто используются как синонимы, и в экономической литературе выделяются их об-

щие черты. Ряд учёных инкорпорируют предпринимательство в качестве составной части в бизнес; к примеру, И. Гапархоев считает, что предпринимательство является структурным элементом бизнеса, базирующимся на активных начинаниях, сопряжённых с риском, и нацеленных на удовлетворение потребностей в продуктах труда. (3, с. 66-69) Другие исследователи придерживаются мнения, что предпринимательство - это особая начальная стадия развития бизнеса. Третья группа экспертов предлагает рассматривать предпринимательство как особую форму бизнеса, характеризующуюся инновационностью, креативностью инициативностью и готовностью к риску, что отличает его от более общего понятия бизнеса.

В изображённой графеме предпринимательство и бизнес условно изображены в виде двух пересекающихся окружностей, в общем секторе которых обозначены схожие черты. Хотя в ней схематически не обозначено развитие предпринимательства в бизнес, но такая перспектива предполагается автором.



Рис. 1. Сходство между бизнесом и предпринимательством

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### Многообразие определений этнического предпринимательства

Основные теоретические концепции этнического предпринимательства иммигрантов получили научную разработку во второй половине XX века. Пионеры нового исследовательского направления, такие как А. Уолдингер и Р. Уорд считают, что этни-

ческое предпринимательство проявляется в деловой активности, осуществляемой этнической группой с использованием ресурсов своего сообщества (финансовая поддержка, клиентура, потребительский спрос в рамках имеющихся возможностей в стране проживания (рыночные условия) и групповых ресурсов (социальный капитал, финансовая

поддержка и этнические сети), что влияет на этническое предпринимательство. Согласно определению, предложенному Р. Уолдингером и соавторами, этническое предпринимательство представляет собой «совокупность связей и закономерностей взаимодействия между людьми, имеющими общее национальное происхождение или миграционный опыт». (4, р. 106–30).

В числе первых учёных России, приступивших к разработке нового направления экономической и социологической науки, был В.В. Радаев, который отметил, что этническое предпринимательство означает специфический способ организации и ведения бизнеса этнических меньшинств в инациональной для них среде. По мнению Радаева, этническое предпринимательство занимает в торговле, производстве и оказании услуг четыре основные ниши:

1. Продажа и производство этнических потребительских товаров для нужд их собственных этнических общин;
2. Завоз товаров из региона (страны) происхождения, исторической родины для реализации иноэтническим потребителям на местном рынке;
3. Удовлетворение разного рода услуг местным потребителям;
4. Заполнение неустойчивых рынков, занятие непрестижными для коренных жителей видами деятельности. (5, с. 79–87)

Российский социолог А.А. Сусоколов определяет этническое предпринимательство как «концентрацию постоянного или временного населения, представляющего в данном регионе этническое меньшинство, в отдельных отраслях хозяйства». Им выделены существенные признаки этнического предпринимательства, в том числе: 1. Этническое предпринимательство — это деятельность, которая связана с сознательным выбором занятий, базирующихся на внутриэтнических социальных сетях. 2. Как правило, этническое предпринимательство можно отнести к частному предпринимательству. 3. Этническое предпринимательство не представляет собой монополизацию какого-либо сегмента рынка представителями одного этноса. 4. Этническое предпринимательство, как правило, опирается на поддержку местных властей. 5. Этническое предпринимательство связано с сокрытием реальных доходов, т. е. с теневой сферой экономики. 6. Взаимоотношения внутри союзов, занимающихся этническим предпринимательством, обычно строятся на общности культуры и моделей поведения. 7. Внутри этнических союзов в случае необходимости включаются механизмы взаимной финансовой поддержки. 8. Этническое предпринимательство распространено в тех экономических нишах, которые слабо развиты и не представляют приоритетного интереса для титульного населения. (6)

Социолог А. Снисаренко также рассматривает этническое предпринимательство как «специфический способ организации и ведения бизнеса этнических меньшинств в инациональной для них среде». (7, с. 139). Экономисты Рунова Н. Ю. и Сагинова О.А. предлагают следующее определе-

ние: «Этническое предпринимательство - это совокупность связей и закономерностей экономического взаимодействия между людьми, имеющими общее национальное происхождение или миграционный опыт». (8, с. 664-670). Этническое предпринимательство, по мнению С. В. Рязанцева, неразрывно связано с этническими миграциями как формой социально-экономической адаптации мигрантов, которые, попав в иную среду, мобилизуют свои внутренние ресурсы и, пытаясь выжить, открывают собственное дело. (9, с. 73–86). Мищук С.Н. считает, что этническое предпринимательство – это набор связей и закономерностей взаимодействия людей, разделяющих общее национальное происхождение или опыт миграции. По её мнению, этническое предпринимательство может рассматриваться в широком смысле как ведение предпринимательской деятельности резидентами или нерезидентами страны, имеющими опыт миграции. В узком смысле предпринимательская деятельность будет носить элемент этничности, если сам организатор бизнеса является мигрантом (или потомком мигрантов), привлекает в качестве рабочей силы иммигрантов и основная доля производимых им товаров и услуг ориентирована на представителей отдельной этнической группы. (10). А.В. Лайша, кандидат философских наук, дал следующее определение: этническое предпринимательство является одним из наиболее эффективных способов адаптации национальных меньшинств в чуждой этнокультурной среде, поскольку способствует повышению социального статуса и достатка мигрантов, занимающихся бизнесом; помогает представителям этнических диаспор установить прочные связи с органами власти, местным бизнесом, правоохранительными структурами; создаёт рабочие места для земляков и соплеменников, тем самым содействуя их адаптации в принимающем социуме. (11, с.12). Тагиров Р. Ю., следуя другим авторам, вместо определения понятия выделил ключевые слова и охарактеризовал наиболее значимые, на его взгляд, признаки, дающие в совокупности представление об этническом предпринимательстве. Первое ключевое слово – диаспора (землячество). Второй признак - малый размер дела; третий - склонность к торгово-посреднической деятельности; четвёртый - прямая или опосредованная связь предпринимательства с сельским хозяйством; пятый - семейно-клановый характер; шестой – влияние традиций и религиозного фактора; седьмой - наличие сильной мотивации к предпринимательской деятельности и восьмой - хорошее взаимодействие с местным населением. В конечном счёте, Тагиров считает, что предпринимательство следует рассматривать, прежде всего, как систему социально-экономических отношений и институт, при этом особо подчёркивает приверженность этнических предпринимателей к торгово-посреднической деятельности. (12, с. 27-53)

Все многообразие определений подтверждает, что этническое предпринимательство означает хозяйственную деятельность, как новых иммигрантов, так и представителей этнических меньшинств, проживающих в стране длительное время.

Чанганти и Грин сравнили определения, данные Уолдингером и другие. и Министерством торговли США, согласно которым иностранные предприниматели могут быть определены как «предприниматели-иммигранты», «этнические предприниматели» и «предприниматели из числа меньшинств». К предпринимателям-иммигрантам относятся люди, которые начинают свой собственный бизнес сразу после приезда, используя свои индивидуальные связи с бывшими иммигрантами и не иммигрантами, имеющими общее происхождение. (13, с.59–75). Этнические предприниматели создают «набор связей и регулярных моделей взаимодействия между людьми, имеющими общее национальное происхождение или миграционный опыт». (14, с. 111-135) Министерство торговли США определяет иностранных владельцев бизнеса как «предпринимателей из числа меньшинств», которые не принадлежат к большинству населения. (15).

В последние десятилетия стали популярными новые подходы и темы исследований предпринимательства. Учитывая невиданные прежде темп и рост числа трансграничных мигрантов из южного в северное полушарие и возникшие острые социальные и экономические проблемы, исследователи обратили пристальное внимание на транснациональное предпринимательство. Предпринимателями-мигрантами, занимая интермедияльное положение между страной-донором и страной-реципиентом используют этнические сети, обеспечивающие доступ к капиталу, информации, рынкам сбыта, ведут сделки в двух или более странах одновременно.

В современный период исчезает прежняя гендерная диспропорция среди иммигрантов, поэтому тема роли женщин в этническом предпринимательстве стала одной из важных направлений в социологии, гендерных и миграционных исследованиях. Учёные анализируют множество вопросов, в том числе: корреляция этнической и гендерной принадлежности в этническом бизнесе; маргинализация женского предпринимательства; роль женщин в семейном бизнесе; гендерные мотивы в формальных и неформальных формах предпринимательства; барьеры и проблемы женщин-предпринимателей. Кроме гендерной, важна возрастная составляющая в этническом предпринимательстве.

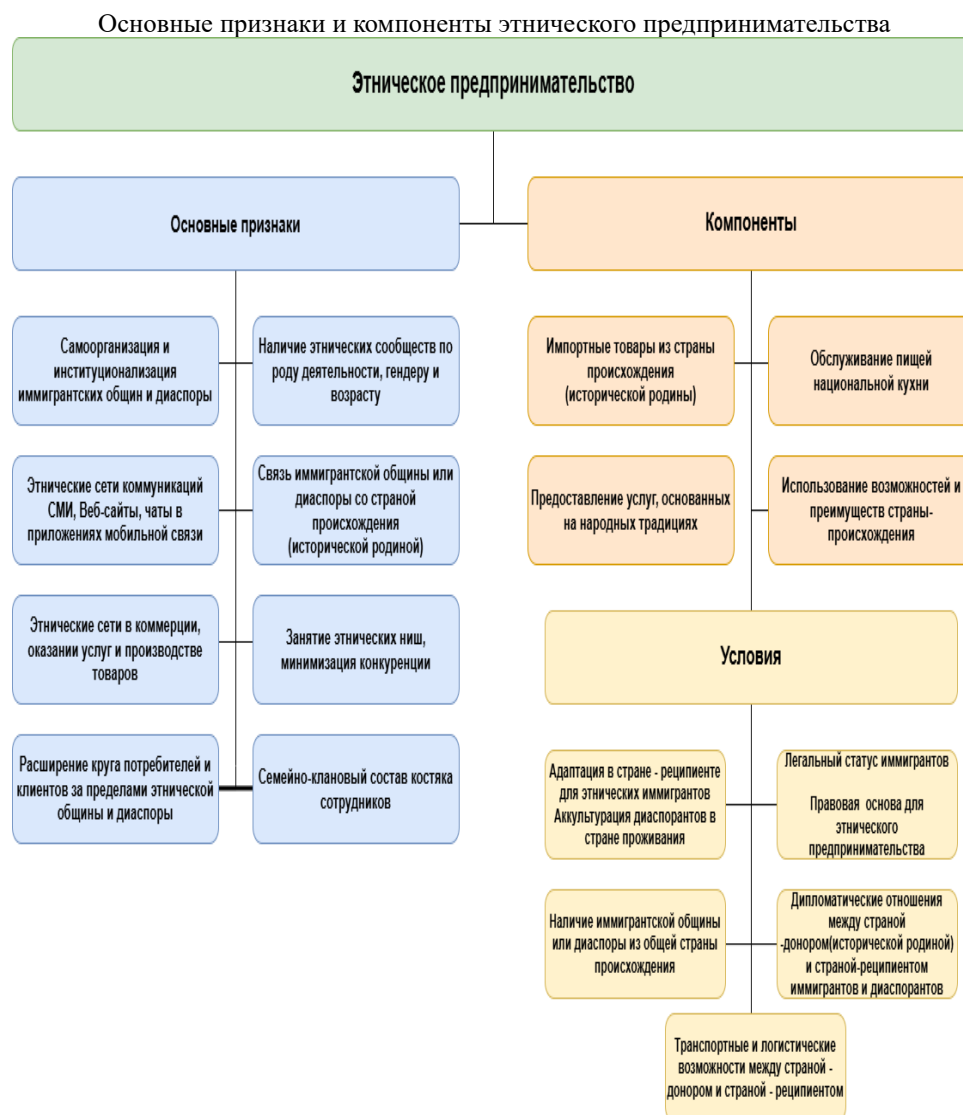
Поколенческие различия наглядно видны в виртуальном (онлайн-овом) предпринимательстве, где доминирует молодёжные когорты, обладающие навыками информационных технологий, смартфонизированные и активно использующие множество приложений, готовые к рискам и экспериментам в зарождающемся и стремительно растущем рынке услуг.

Расширение парадигмы и дискурса актуальной темы научных исследований закономерно приводит к появлению энциклопедических трудов и специальных справочных изданий. Под редакцией профессора Лео-Пол Дана вышел «Справочник исследований предпринимательства этнических меньшинств». (16). Энциклопедическое издание,

подготовленное международной группой учёных, состоит из восьми частей и 49 глав, общим объёмом 835 страниц. В этом фундаментальном междисциплинарном труде рассматриваются вопросы, связанные с иммиграцией и предпринимательством этнических меньшинств с середины двадцатого века до начала текущего столетия. Международные авторы на примере множества этнических меньшинств, доказывают, что их предпринимательство существенно влияет на национальные экономики. Они внесли существенный вклад в анализе факторов, способствующих успешному предпринимательству и путей минимизации негативных последствий, с которыми сталкиваются успешные предприниматели из миноритарной этнической среды.

В Казахстане тема этнического предпринимательства стала привлекать внимание молодых учёных, которые пытаются найти свой фокус научных исследований. Имашева Ж.А и Абдирайымова Г.С. опубликовали статью о концептуализации понятия этническое предпринимательство как объекта социологического анализа. Авторы на основе анализа зарубежной историографии пришли к выводу, что этническое предпринимательство стало важным аспектом современной городской жизни и выполняет ключевую экономическую и социальную роль для этнических сообществ. (17, с. 85–93).

Группа российских и казахстанских авторов: С.Г. Симонов, О.В. Ямова, М.А. Хаматханова и З.А. Арынова считают, что по базовым критериям этническое предпринимательство, как правило, относится к средним и малым формам хозяйствования и занимает значительную долю региональных потребительских рынков. При этом каждая этническая общность обладает своей рыночной нишей. (18, с. 163-171). Этническое предпринимательство - неотъемлемая часть любой миграции, что наиболее очевидно в Соединённых Штатах, где в малом бизнесе преобладают выходцы из других стран. Америку (США) образно называют планетой иммигрантов, так как в ней самый высокий в мире показатель числа иммигрантов. В 2023 году в США проживало более 47,8 миллионов иммигрантов, что составляет около 14,3% населения. Поэтому закономерно, что именно в этой стране зародилось и получило развитие этническое предпринимательство. Ранняя и ставшая известной теория предполагает, что этническое предпринимательство стало очевидной реакцией на ограниченные возможности иммигрантов на рынке труда, выходящие за пределы 3D jobs, что во многих случаях остаётся актуальным и в наши дни. Европа, напротив, оставалась этнически однородной вплоть до Второй мировой войны, когда быстро растущим промышленным предприятиям потребовалось увеличение трудовых ресурсов. Сначала иммигранты приезжали как временные рабочие, выполнявшие низкоквалифицированную работу, не требовавшую никаких навыков и которую могли исполнять любые приезжие иностранцы.



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В исследованиях по этническому предпринимательству довольно часто ставится знак равенства с этническим бизнесом, однако эти взаимосвязанные понятия не тождественные. Этническое предпринимательство - это более широкое понятие, которое охватывает всю деятельность представителей определённой этнической группы, направленную на создание и развитие бизнеса. Оно включает в себя все основные признаки присущие предпринимательству. В свою очередь, этнический бизнес можно определить, как предприятия и компании, принадлежащие этническим иммигрантам или диаспорантам.

Один из самых признанных научных экспертов этно-предпринимательства в США Иван Лайт одним из первых выдвинул концепцию «этнической экономики», утверждая, что этнические предприниматели используют внутренние связи и доверительные отношения внутри этнической группы для экономического роста. (19, с. 195–216). Он написал сам и опубликовал в соавторстве десятки статей и глав в монографиях об предпринимательстве избранных

для исследования этнических иммигрантов, раскрыл многие этнические аспекты деловой активности. (20, 21.)

Роджер Уолдингер сам и совместно с коллегами рассматривает этническую экономику как систему, обеспечивающую занятость как в формальном, так и в неформальном секторах. Указанные исследователи приходят к одинаковому выводу о том, что этнический бизнес действует на микроуровне - конкретных предприятий: магазинов, кафе, мастерских, мелких торговых и сервисных фирм. В то время как этническая экономика охватывает более широкие макроэкономические и социальные процессы, включая рынок труда, профессиональную занятость, внутренние и трансграничные миграционные потоки и так далее. ( 22, с. 111-135 ).

Известные учёные, такие как Портес и Жоу считают, что этнический бизнес является важной составляющей этнической экономики, включающей в себя не только малый и средний бизнес, но и особенности трудовой занятости, миграционные потоки рабочей силы, неформальные формы экономической активности внутри этнических общин в

виде кассы взаимопомощи, теневых рынков, семейных предприятиями. Портес и Жоу указали, что этническая экономика не просто ниша, а динамичная система с потенциалом для роста и интеграции в общенациональную экономику. (23, с. 491–522).

Концепции этнической экономики исходят главным образом из утверждения, что иммигранты, принадлежащие к меньшинству в принимающей стране, сталкиваются с особой ситуацией, которая, с одной стороны, является неблагоприятной (как и положение любого меньшинства). С другой стороны, иммигранты обладают дополнительными ресурсами, которые принято называть «этническими». По мнению Лайта и Розенштейна, этнические ресурсы - это ресурсы, основанные на идентификации человека с этнической общностью. (21).

«Этнические» ресурсы не только позволяют иммигрантам обустроиться в новой стране, но и определяют их экономические стратегии. Это явление определяется как «этническая экономика». Экономика является этнической, потому что ее трудовые ресурсы состоят из коэтников (соплеменников) из общей исторической родины или страны-донора эмигрантов. Лайт и Карагеоргис утверждают, что люди, как представители этнического меньшинства, имеют возможность объединяться на основе общей этнической принадлежности и заниматься совместной предпринимательской деятельностью. Это также подразумевает, что они доверяют друг другу только потому, что принадлежат к одной и той же этнической группе. Доверие, основанное на общей этнической идентичности, играет ключевую роль. Оно позволяет создавать так называемые «этнические» социальные (или экономические) сети. Благодаря этому доверию облегчается обмен информацией внутри таких сетей. Кроме того, оно способствует снижению вероятных транзакционных издержек, возникающих из-за недоверия, примером чему может служить уменьшение необходимости в посредниках, выступающих гарантами в бизнесе. (20).

Научные понятия и обиходные словосочетания «этническая экономика», «этнический бизнес» и «этническое предпринимательство» имеют в своей основе категорию этничности, которая играет ключевую роль в определении их содержания и границ. То есть основным объединяющим фактором участников предпринимательской деятельности выступает именно их этническая принадлежность. Она является детерминирующим фактором, влияющим на доступ к ресурсам; способы и формы предпринимательской активности; формирование этнических сетей; методы мобилизации стартового капитала и модели поведения. Однако этничность в контексте предпринимательства проявляет динамичность, так как по ходу могут происходить изменения в идентичности и ослабление этнических связей по мере укрупнения бизнеса, для которого необходим рост числа потребителей и клиентов не зависимо от этнической принадлежности.

Этнокультурные факторы оказывают влияние

на решение начать собственное предпринимательство, масштабировать или свернуть его. Сторонники культурологического подхода считают, что этнические иммигранты обладают культурно обусловленными особенностями, приводящими в конечном итоге к samozанятости. (24, с. 238:260). Другой подход, основанный на структурализме, предполагает, что внешние факторы в принимающей среде, такие как дискриминация или барьеры на рынке труда из-за недостатка образования и языка, толкают иностранцев к samozанятости. Некоторые исследователи пытаются объединить эти две точки зрения и утверждают, что для понимания сложного явления необходим дифференцированный подход. На современном этапе произошёл отход от стереотипного и лапидарного представления об этническом предпринимательстве как об овощном магазинчике на углу с хозяином-иммигрантом в сторону более диверсифицированных секторов этнического бизнеса экономики. По мнению экспертов, в этнической экономике мелкое предпринимательство в иммигрантской среде будет продолжать возникать, сохраняться и развиваться как возможность жизнеобеспечения в принимающей стране. Однако в процессе диаспоризации иммигрантов этническое предпринимательство будет перестать в мелкий и средний этнический бизнес с расширенным за пределы земляческого сообщества кругом потребителей товаров и услуг. Этнический бизнес малых и средних размеров охватывает торговлю товарами с расширенной добавочной стоимостью (бытовая электротехника, электроника, брендовая косметика и т.д.), организация досуга и отдыха, агентства недвижимости и др.

### **Этническое предпринимательство среди зарубежных корейцев**

В статье предлагается авторское синтезированное определение «этнического предпринимательства» как экономической деятельности предпринимателей-иммигрантов, использующих этническую сеть землячества, ресурсы и потребительский рынок коэтников и связь с исторической родиной или страной-происхождения. ( 25, с. 74-81). Экстраполируя эту дефиницию в диаспорные исследования, доказывається зарождение и существование «этнического предпринимательства» среди корейцев в Советском Союзе, современных странах Центральной Азии и за ее пределами, где проживают численно значимые общины коре сарам – русскоязычных корейцев. Новизна исследовательского труда заключается в исследовании феномена «этнического предпринимательства» не в иммигрантской, а диаспорной среде, зародившегося в условиях директивной, плановой социалистической экономики, в которой исключалась частная собственность, частный капитал, «нетрудовые доходы», наёмный труд и так далее.

Этническое предпринимательство как специфический способ организации и ведения бизнеса иммигрантскими этническими сообществами в стране-реципиенте, прежде всего в США рассмат-

ривалось в научных трудах ряда американских учёных. Несмотря на разницу анализируемых аспектов предпринимательства и этнических групп, всех исследователей объединяет недавнее трансграничное иммигрантское происхождение предпринимателей. В этой связи следует отметить, что механизмы становления и развития этнического предпринимательства в Советском Союзе отличались от таковых в США и других западных странах. Поэтому западные концепции связей этничности и предпринимательства следует экстраполировать в советские реалии только путём критического анализа и верификации заимствованных идей.

По понятным причинам наиболее исследованными среди зарубежных корейцев оказались корейские иммигранты в США. Особенности формирования этнической сети предпринимательства среди американских корейцев исследовались такими учёными как: Ким Хён Чана, Эн Хо Ли, Ким Ильсу, Квак Тэ Хва, Мин Пён Гап, Ю Ёй Ён, Пак Кё Ён, Юн Ин Чжин (26, 27, 28, 29, 30, 31) и многие другие.

Виды предпринимательской активности корейских резидентов в Японии получили разработку в научных трудах Абэ Кадзухиро, Митчелла Ричарда Х., Сони Рян, Вайнера Майкла, Фукуока Ясунори, Рэндса Дэвида, Ли Джона (32, 33, 34, 35, 36, 37, 38) и других.

Появились научные исследования об иммигрантском предпринимательстве корейцев в Канаде (39, с. 39:61), Австралии (40, с. 80:86), Новой Зеландии (41, с. 94:109), странах Европы (42), Южной Америки (43, с. 373:392) и Юго-Восточной Азии. (44, с. 321:364), России и странах Центральной Азии (45).

Этническое предпринимательство корейских иммигрантов имеет общие черты, так как речь идёт о людях, живущих в разных странах и регионах мира в первом поколении, поэтому схожих по своему менталитету и социокультурному облику. Прежде всего иммигранты первого поколения полагаются прежде всего на семью и поэтому предпринимательство носит семейный характер. Как правило, семейные пары торгуют или оказывают услуги, а дети подросткового возраста помогают родителям. Предпринимательское дело и мелкий бизнес передаётся по наследству и часто несколько

поколений одной семьи трудятся в одном деле. Предприниматели-иммигранты ориентируются на клиентов-соплеменников и этнические ниши. На начальном этапе иммиграции корейские предприниматели часто обслуживают своих соотечественников и другие азиатские диаспоры, в сфере питания (кафе, закусочные и рестораны), торговли (магазины, мини-маркеты) и оказания услуг на родном языке: парикмахерские, массажные салоны, лечебные кабинеты и т.д. Позже, когда иммигранты усваивают язык среды обитания и адаптируются к условиям местного рынка они меняют ассортимент, подстраиваются под вкусы и предпочтения местного населения. Этническое предпринимательство иммигрантов следует рассматривать не только как способ выживания, но и как путь к социальной мобильности, укреплению положения семьи в принимающем обществе, обеспечение качественного образования детей, что станет залогом достижения успехов.

Диаспорное предпринимательство диаспоры, как отмечается в новейших исследованиях, представляет собой многослойную, институционально оформленную и системно ориентированную экономическую деятельность. Оно базируется на длительном, многопоколенном опыте диспорантов, являющихся гражданами страны проживания, ставшей для них реальной родиной. Диаспорное предпринимательство использует этнические, национальные и транснациональные сети и медиаторские возможности. Для диаспорного предпринимательства характерна диверсифицированная структура, в которую входят на современном этапе финтех, информационные технологии, инвестиционные проекты сервисы B2B, агробизнес, выход на международные рынки, партнёрство с этнической родиной. В отличие от стратегии иммигрантского предпринимательства, ориентированного на выживание и этническую нишу, использование иммигрантской сети клиентов и партнёров, диаспоральные стратегии предпринимательства направлены на долгосрочное планирование, создание многоуровневых экономических экосистем, использование диаспорной сети как дополнительного, а не ключевого ресурса. Диаспорное предпринимательство имеет тенденцию трансформации в бизнес, преимущественно малого и среднего уровня.



Таблица 3.

## Этническое предпринимательство зарубежных корейцев в сравнении

| Регион                                     | Основные виды бизнеса                                      | Особенности взаимодействия с рынком                                               | Роль общины и семьи                                                             | Примеры                                                                                                                       |
|--------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Северная Америка (США, Канада)             | Магазины, салоны красоты, рестораны, химчистки             | Быстрая адаптация, агрессивное освоение локальных рынков                          | Сильная роль семьи, активное участие корейских церквей, кредитные сообщества    | Лос-Анжелес, Нью-Йорк, кореатауны, успехи в нишах этнического предпринимательства                                             |
| Европа (Германия, Франция, Великобритания) | Рестораны, косметические салоны, магазины, торговля        | Медленный выход на широкий рынок, приверженность к этническим нишам               | Семейный бизнес, сильная роль земляческих и религиозных объединений             | Корейские кварталы в Париже, Берлине, Лондоне                                                                                 |
| Азия (Китай, Япония, Вьетнам)              | Производство, рестораны, торговля, салоны красоты          | Быстрая интеграция в местную экономику                                            | Семейное предпринимательство, высокая конкуренция с другими азиатскими этносами | Яньбянь-Корейский автономный округ. Бизнес-сети корейских организаций «Миндан» и «Чхочонрён». Туризм для корейцев во Вьетнаме |
| Центральная Азия (Казахстан, Узбекистан)   | Сельское хозяйство, розничная торговля, салоны, услуги     | Высокий уровень доверия в социуме, активный выход на межэтнический рынок          | Экономическая опора на семью, поддержка корейских организаций                   | Корейские колхозы. Кобонджи. Корейские рынки в Ташкенте. Успехи корейцев в крупном бизнесе Казахстана                         |
| Южная Америка (Бразилия, Аргентина, Перу)  | Торговля, текстиль, рестораны, косметика                   | Ниши на рынках, приверженность обычаям и традициям, сохранение корейской культуры | Семейная модель, активное участие в корейских ассоциациях                       | Корейский квартал в Сан-Паулу, развивающийся рынок корейской косметологии                                                     |
| Австралия и Новая Зеландия                 | Маникюрные салоны, рестораны, мини-маркеты, бытовые услуги | Быстрая ориентация на местный спрос, стремление выйти за пределы этнических ниш   | Семейный бизнес, поддержка через церковные и культурные объединения             | Значительная доля корейского сегмента на рынке косметологических услуг, косметики; корейские рестораны в Сиднее и Мельбурне   |

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### Заключение

Этническое предпринимательство несмотря на научную и прикладную актуальность и значимость остаётся, как и прежде в зоне исследовательских белых пятен. Западные учёные, исходя из теоретических и прагматических целей, изучили множество примеров бизнеса иммигрантов, построенного на использовании этнических сетей. Однако многие методологические принципы анализа и теоретические конструкции, использованные зарубежными авторами, не вписываются в матрицу действительности этнических диаспор, которые существенным образом отличаются от иммигрантских этнических сообществ. Отличие от иммигрантов, не уверенных останутся ли они в принимающей стране (host country), сохранивших гражданство страны происхождения и слабо аккультурированных в мейнстриме (mainstream), диаспоранты (представители

диаспоры) признают страну проживания своей реальной родиной, гражданами которой они являются и глубоко интегрированы в среде проживания. У диаспорантов в отличие от иммигрантов сформированная множественная идентичность: гражданская, этническая и диаспорная, которая отличает их от коэтников исторической родины и в других странах.

Этническое предпринимательство диаспоры или диаспорное предпринимательство возникло и развивалось под влиянием внешних и внутренних факторов. К внешним детерминантам отнесены правовые основы предпринимательской деятельности; состояние национальной экономики; конкурентная иноэтническая среда; характер отношений реальной родины с исторической родиной. Внутренние предпосылки заключаются в активности диаспоры по созданию своих этнических сетей,

менталитете диаспоры, социально-экономическом статусе (имидже) диаспоры, предрасположенности к определённым видам деятельности и так далее.

Сравнительный анализ западных и постсоветских традиций изучения этнического предпринимательства позволил верифицировать ключевые понятия; определиться с основными теоретическими концепциями, методологическими принципами исследования. Исследование строилось на силлогизме разности предпринимательства и бизнеса, что несмотря на общность цели и основных задач этих двух видов экономической деятельности, между ними не может быть знака равенства. Второй силлогизм заключается в том, что предпринимательство и этническое предпринимательство имеют как сходства, так и существенные различия.

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## TRANSFORMING GEORGIA'S ECONOMIC MODEL: A REVIEW OF RECENT STUDIES ON THE CIRCULAR ECONOMY

(Based on the studies by D. Prasek, S. Pavliashvili, M. Kimeridze, and M. Chelidze: "Assessment of the Level of Circularity of Georgia's Economy, 2022" and "Circularity Roadmap for Georgia, 2024")

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### Abstract

This review is based on recent comprehensive research that provides, for the first time, a full assessment of Georgia's current level of circularity and the potential pathways for transitioning to a new economic model, the circular economy. As a relatively new concept in the Georgian context, the circular economy introduces an innovative framework for guiding the country's strategic shift toward sustainable and resilient economic development.

**Keywords:** Circular economy, Georgia, sustainable development, economic transformation, circularity assessment.

### Introduction

In recent years, Georgia has undertaken its first large-scale studies paving the way for a transition from a linear to a circular economic model. Recent research provides the first comprehensive assessment of the country's circularity level (1.3%) and outlines a strategic pathway to increase it to 6.6% over the next decade (Prasek et al., 2024).

These studies address global challenges such as resource depletion and climate change, highlighting the importance of the circular economy for both economic and environmental sustainability. The analysis covers 14 key sectors and employs an innovative methodology (RME model), enabling, for the first time, an accurate evaluation of actual resource use in Georgia.

Together, these works establish a new economic vision for Georgia, a development model rooted in resource reuse, innovation, and ecological responsibility, aligning the country with the European Green Deal and generating new economic opportunities.

### Why This Is Important

Humanity now lives in the so-called Anthropocene, an era in which economic activity increasingly disrupts the balance of nature. Globally, only 8.6% of the economy is circular, meaning that most resources are simply extracted, used, and discarded. This "linear" model ("take–make–dispose") depletes natural resources and accelerates climate change (Pavliashvili & Tokmazishvili, 2024).

Projections indicate that material consumption could double between 2015 and 2050 due to a global population increase of approximately 500–750 million per decade, along with rising living standards and purchasing power in less developed regions. Additionally, about 20% of globally extracted materials become waste, representing a significant environmental burden.

The circular economy provides an alternative approach, promoting multiple-use cycles for resources, minimizing waste, and closing production loops. This model is being adopted by European Union countries in

their transition toward green and sustainable economies, and Georgia is now following a similar path.

In December 2015, the European Commission adopted the "Ambitious Circular Economy Package," which included updated legislation on waste management (European Commission, 2015; European Parliament Research Service, 2016). On 12 March 2020, the Commission approved a new "Circular Economy Action Plan" as a key component of the European Green Deal, introducing a new framework for sustainable development (European Commission, 2020). In recent years, European cities, regions, and countries have actively developed circular economy strategies; from 2014 to the present, 33 strategies have been adopted, with at least 29 more in progress (European Circular Economy Stakeholder Platform, 2019).

Currently, Georgia's economy is only 1.3% circular, meaning it still functions almost entirely linearly. The strategic goal is to raise this share to 6.6% over the next decade. This ambitious yet achievable target is promising, as effective resource management can help the country protect the environment, create jobs, and attract investment.

Georgia is emerging as a regional leader in accelerating the transition to a circular economy. By 2050, the country aims to establish a society in which circular economy principles are embedded in everyday life, fostering sustainable production and consumption patterns.

### Two Studies — One Big Idea

Between 2020 and 2022, GSNE "Orchis" prepared the *Assessment of the Level of Circularity of Georgia's Economy*. Conducted by a 13-member working group of both international and local experts, the 24-month study concluded in October 2022. Throughout the process, the experts closely collaborated with the Inter-agency Coordination Council of the Government of Georgia, chaired by Academician Solomon Pavliashvili. The council's effective coordination significantly contributed to achieving the project's objectives. The study provides a comprehensive diagnosis of Georgia's

current situation, highlighting the inefficient use of resources.

The next phase, carried out in 2023–2024, produced the *Circularity Roadmap for Georgia*. Prepared with the support of the United Nations Development Programme (UNDP) and Sweden under the Governance Reform Fund (GRF), this study serves as an actionable roadmap, outlining concrete steps to transform the system in ways that benefit both the economy and the environment. Together, these studies complement each other: the first answers “Where are we?” while the second addresses “Where should we go?”

The initial study reveals that Georgia’s economy is currently only 1.3% circular. The roadmap outlines a vision to increase this share to 6.6% over the next decade. The authors conducted a detailed analysis of 14 key sectors, which collectively account for more than half of GDP (52.9%). These sectors include agriculture, energy, construction, manufacturing, and mining — areas where targeted changes are expected to have the greatest impact (Prasek et al., 2024).

### Key Innovations Introduced by This Research

The authors developed a systematic methodology and an innovative assessment framework that integrates both economic and environmental indicators. They applied the Raw Material Equivalents (RME) model, uncommon in developing countries, providing for the first time a realistic assessment of Georgia’s actual resource consumption.

The study also establishes a sectoral vision, analyzing 14 key sectors that together account for nearly half of GDP (52.9%). Special attention is given to agriculture (wine and livestock), energy, construction, and mining. The research highlights the interconnections among these sectors and demonstrates how their collaboration can foster a circular economy.

A strategic vision is outlined along four main circularity directions: narrowing, slowing, restoring, and cycling of resource flows, with guidance on implementation in each sector. For example, construction focuses on using secondary materials and regulating demolition; food production emphasizes waste reduction and prioritizing local products; and industry focuses on digital technologies to optimize resource efficiency.

The circular economy is not solely a technological challenge. The authors advocate a multi-dimensional approach that emphasizes education, culture, and awareness. They argue that circular thinking should start in schools and continue through professional education, helping society understand that waste can be a starting point for new products rather than mere discard.

The study also provides practical policy recommendations for government and private sector actors, including the distribution of responsibilities among the state, municipalities, and businesses, creating an investor-friendly environment, and simplifying regulations.

Finally, the research underscores that the circular economy can serve as a cornerstone for Georgia’s economic stability and financial security.

### The First Step Toward a New Economy

The monographs have already become a foundation for dialogue among government, business, and academic stakeholders, helping to shape a national vision that integrates economic, environmental, and social responsibility.

In Georgia, the circular economy is no longer merely a theoretical concept; it has emerged as a concrete development strategy that aligns the country’s European aspirations with global green policies.

This research goes beyond environmental objectives: it generates new economic opportunities, strengthens business resilience, and fosters innovation.

More than a report, the study serves as a roadmap for transitioning Georgia from a linear economy to a model in which resources are fully reused, waste is minimized, and sustainability is prioritized. It represents a step toward an innovative, human-centered future aligned with European standards. The circular economy is no longer just a scientific concept; it has become an integral part of Georgia’s national agenda.

### Conclusion

The circular economy provides Georgia with a pathway to sustainable development through innovative approaches that integrate economic, environmental, and social priorities. By leveraging novel methodologies, sector-specific strategies, and technology-driven solutions, the country can improve resource efficiency, generate new economic opportunities, and enhance resilience. This research offers a practical, innovation-focused roadmap for transitioning from a linear to a circular economy, representing a decisive step toward a sustainable and future-ready economy.

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# BRANDING, SOCIAL MEDIA ENGAGEMENT, AND CUSTOMER PERFORMANCE OF DEPOSIT MONEY BANKS IN LAGOS STATE, NIGERIA

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## Abstract

The increasingly competitive landscape of Nigeria's financial sector has compelled Deposit Money Banks (DMBs) to strengthen their branding strategies to enhance customer acquisition, retention, and loyalty. Despite the acknowledged importance of branding in shaping customer perceptions, empirical evidence suggests that Nigerian DMBs have not effectively aligned their branding initiatives with measurable customer performance outcomes. Moreover, the rapid rise of fintech firms has disrupted traditional banking structures, underscoring the need for DMBs to leverage digital engagement particularly social media as a strategic branding and customer relationship management tool. This study investigates the effect of branding on customer loyalty among selected DMBs in Lagos State, Nigeria, and examines the moderating role of social media engagement in this relationship. Adopting a cross-sectional survey design, data were collected from 687 respondents using a structured questionnaire. The data were analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS 4.0. The results reveal that branding has a positive and statistically significant effect on customer loyalty ( $\beta = 0.462$ ,  $t = 7.921$ ,  $p < 0.05$ ), indicating that strong brand equity fosters customer retention and commitment. Additionally, social media engagement significantly moderates the relationship between branding and customer loyalty ( $\beta = 0.287$ ,  $t = 4.613$ ,  $p < 0.05$ ), suggesting that active digital interaction amplifies the positive influence of branding on customer attachment and satisfaction. Further assessment of the structural model confirms predictive relevance ( $Q^2 > 0$ ) and robustness in explaining the interplay between branding, social media engagement, and customer performance. The study concludes that branding dimensions such as brand identity, image, positioning, and reputation are critical drivers of customer performance among DMBs in Lagos State. Furthermore, social media engagement serves as a vital moderating capability that enhances the effectiveness of branding strategies and strengthens customer loyalty. The study recommends that DMBs should strategically invest in social media engagement by maintaining active interactions with customers, promptly responding to inquiries, and sharing brand-aligned content. Highlighting customer testimonials, success stories, and loyalty initiatives across digital platforms can significantly reinforce brand credibility, deepen customer trust, and sustain long-term loyalty in Nigeria's competitive banking environment.

**Keywords:** Branding, Social Media Engagement, Customer Loyalty, Customer Performance, Deposit Money Banks, Lagos State, Nigeria

JEL classification: G21, M31, L84, O33

## 1. Introduction

The Nigerian financial system has witnessed unprecedented market turbulence, with Deposit Money Banks (DMBs) constantly competing for customer acquisition to sustain their market share and profitability (Asikhia et al., 2022; Onamusi & Adekunle, 2025). Although aggressive acquisition strategies have strengthened banks' outreach, their failure to deliver excellent customer experience continues to undermine brand trust and customer retention (Adekunle & Onamusi, 2025). A decade-long KPMG customer experience survey (2012–2024) revealed that Nigerian DMBs consistently fell short of the six core dimensions of excellent customer experience, indicating systemic weaknesses in customer-centric service delivery (Bhattacharya, 2022; Kadri & Onamusi, 2025).

The recent currency redesign and cash scarcity crisis, driven by the Central Bank of Nigeria's (CBN) new naira policy, further exposed operational inefficiencies and the fragile trust relationship between banks and customers (Onamusi & Adekunle, 2025). While traditional banks struggled with service breakdowns, fintech companies such as Opay, Palmpay, and Moniepoint

emerged as more reliable alternatives. Preliminary evidence suggests that between February and July 2023, the number of retail outlets and customers adopting these neobanks tripled, underscoring a significant shift in consumer confidence and transactional preferences (Truong, 2024). This trend has triggered concern among conventional DMBs as they continue to lose market share and unrealized profits to agile fintech competitors.

In this increasingly dynamic and digitalized environment, branding has become a strategic imperative for DMBs seeking to preserve customer trust and long-term competitiveness. A strong brand signals reliability, consistency, and integrity; attributes that enhance customer confidence in a firm's products and services (Onamusi & Ayo, 2021). This trust, in turn, fosters higher satisfaction, loyalty, and repeat patronage (Sitorus & Yustisia, 2018). Effective branding also enables DMBs to differentiate themselves in a highly commoditized market by cultivating emotional connections and projecting a consistent image that adapts to evolving customer needs (Sitorus & Yustisia, 2018). From this perspective, branding functions not merely as

a marketing tool but as a strategic asset that supports customer-oriented innovation and sustainable competitive advantage (Kadri & Onamusi, 2025).

However, despite the consensus on the relevance of branding to firm performance, many Nigerian DMBs appear to lack a strategic understanding of how branding can be leveraged to influence specific customer performance outcomes such as satisfaction, preference, and loyalty. This conceptual deficiency often manifests in fragmented brand communication, inconsistent customer service, and limited emotional resonance with target audiences. A review of extant literature reveals that most empirical studies on branding have been conducted in sectors such as telecommunications, fast-moving consumer goods (FMCGs), hospitality, and entertainment (Adarkwah & Malonæs, 2020; Harris & De Chernatony, 2001; Islami et al., 2024; Onamusi & Ayo 2021). Few studies have systematically examined the nexus between branding and customer performance within Nigeria's banking sector, particularly among DMBs in Lagos State, Nigeria's financial epicenter (Kadri & Onamusi, 2025).

Moreover, the rise of social media engagement introduces new dynamics into the branding–customer relationship paradigm. Social media platforms now constitute critical spaces for brand communication, customer interaction, and reputation management (Onamusi, 2021). Through social engagement, banks can enhance brand visibility, promote transparency, and foster two-way communication that humanizes the brand (Khadijat, 2023; Quesenberry, 2020; Akin-Odukoya, 2024). Engaging customers through interactive content, storytelling, and personalized responses strengthens brand recall and nurtures relational trust. By sharing success stories, corporate social responsibility activities, and community impact initiatives, banks can build deeper emotional connections with stakeholders (Kouamé et al., 2022).

Despite these strategic opportunities, there is limited empirical evidence on how social media engagement moderates the interaction between branding and customer performance outcomes in the Nigerian banking context. Existing marketing literature has not sufficiently explained whether and how digital engagement amplifies or weakens the effectiveness of branding strategies in influencing customer loyalty and satisfaction. This gap is particularly relevant for DMBs in Lagos State, where digital financial interactions dominate customer experience ecosystems. Consequently, this study seeks to address the gaps by examining the influence of branding on customer performance and assessing the moderating role of social media engagement among DMBs in Lagos State, Nigeria.

## 2. Literature Review

### *Theoretical Underpinning*

The Dynamic Capability Theory (DCT) emerged as an extension of the Resource-Based View (RBV) to address one of its key limitations the RBV's static orientation toward firm resources (Arndt, 2019; Onamusi, 2020). While RBV explains firm performance through the possession of valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney, 1991), it does

not sufficiently account for how firms sustain competitive advantage in volatile and technologically dynamic environments. To bridge this gap, Teece, Pisano, and Shuen (1997) conceptualized DCT as a framework that emphasizes a firm's ability to integrate, build, and reconfigure internal and external competencies in response to environmental changes (Asikhia., 2020; Onamusi et al., 2019; Vartiainen, 2023). Hence, DCT extends the RBV from a focus on what resources a firm possesses to how effectively it renews and deploys them to sustain advantage over time. This theoretical shift underscores that resources alone do not guarantee performance; rather, it is the firm's dynamic capabilities; its knowledge, skills, and adaptive processes that determine its capacity to remain competitive amid disruption (Teece, 2019).

According to Teece (2019), dynamic capabilities are underpinned by three interrelated components: adaptive capability, absorptive capability, and innovative capability. Adaptive capability reflects a firm's agility to reconfigure resources swiftly in response to market turbulence while maintaining operational efficiency (Romain, 2020; AlMulhim, 2023). Absorptive capability involves the identification, acquisition, and assimilation of external knowledge to strengthen internal competencies and innovation potential (Sjödin et al., 2019; Kale et al., 2019). Innovative capability represents a firm's capacity to continuously create new products, services, and processes that align with evolving market expectations (Kapoor & Teece, 2021; Danneels, 2002).

These dimensions collectively enable firms to sense, seize, and transform opportunities in dynamic environments, thereby maintaining long-term competitiveness (Jiang et al., 2020; Alateeg & Alhammadi, 2024). In highly turbulent sectors such as banking, where digital technologies and customer preferences evolve rapidly, these dynamic mechanisms are critical for sustaining market relevance and customer trust.

Despite its growing influence, DCT has been critiqued for conceptual ambiguity and limited empirical operationalization (Wilden et al., 2013). Some researchers argue that dynamic capabilities are difficult to measure and may not directly translate into competitive advantage without complementary resources and contextual alignment (Ferreira & Coelho, 2020). Others contend that their effects are often indirect, mediated by firm-level processes or environmental factors (van Lieshout et al., 2021). Nonetheless, recent meta-analyses and cross-disciplinary studies confirm the theory's robustness and versatility, highlighting its significant role in explaining firm adaptability, innovation, and performance in diverse contexts such as entrepreneurship, technology management, and marketing (Teece, 2019; Fabrizio et al., 2022; Habig et al., 2020).

This study is theoretically anchored on both the Resource-Based View (RBV) and the Dynamic Capability Theory (DCT) because they jointly explain how branding and social media engagement contribute to customer performance in Nigeria's Deposit Money Banks (DMBs). Within the RBV framework, a bank's brand equity represents a valuable, rare, and inimitable resource that enhances customer trust, satisfaction, and

loyalty (Sitorus & Yustisia, 2018). A strong brand, therefore, acts as a strategic asset that differentiates the bank in a competitive market and drives sustainable customer relationships (Nguyen et al., 2020; Onamusi & Ayo, 2021). However, in a digitalized financial environment characterized by rapid technological advancement and shifting consumer behavior, possessing a strong brand is insufficient without the capability to adapt and reconfigure it. This is where DCT becomes relevant: it explains how DMBs can leverage dynamic mechanisms such as social media engagement to renew customer relationships, enhance brand relevance, and sustain performance outcomes. Social media engagement represents an adaptive and absorptive capability; a means through which banks sense customer needs, absorb market feedback, and transform interactions into customer-centric innovations (Khadijat, 2023; Onamusi, 2021; Quesenberry, 2020; Akin-Odukoya, 2024).

Integrating DCT with RBV thus provides a more holistic lens for analyzing how DMBs achieve and sustain customer performance. While RBV emphasizes brand equity as a resource, DCT highlights social media engagement as a dynamic capability that ensures this resource remains valuable and relevant in an evolving market. This theoretical synergy reflects (1997) argument that sustainable performance arises from the interplay between a firm's resource base and its dynamic ability to adapt those resources to changing conditions. In the context of Lagos State DMBs, where competitive intensity and digital disruption are exceptionally high, the dual application of RBV and DCT explains both the possession and renewal of strategic assets. DMBs that effectively combine strong brand equity (a resource-based advantage) with high levels of social media engagement (a dynamic capability) are more likely to build customer loyalty, satisfaction, and long-term relational value. Hence, on the strength of this theoretical integration, the study hypothesize that: *H<sub>1</sub>: the interaction between branding and customer performance of DMBs in Lagos State is significantly moderated by social media engagement.*

#### *Branding, Social Media Engagement and Customer Performance*

After reviewing strategic marketing management literature, evidence of empirical submission of how social media engagement moderate the relationship between branding and customer performance is largely unknown and this suggest this is first study to explore this interaction. In the event of this development, the researcher explored theoretical explanation and the conceptual relevance of social media engagement to position how the interaction can happen and path through which the interaction can be positioned. With respect to the theory, this study considered the contingency theory of fit as a moderator as noted by a scholar (Naidu et al., 2023). *According to the author, "When contingency theorists assert that there is a relationship between two variables ... which predicts a third variable... they are stating that an interaction exists between*

*the first two variables", hence accentuating the attractiveness of the interaction perception in organisational studies.*

According to the interaction perception, the effect that an independent variable (branding) has on a dependent variable (customer performance) is contingent on the level of a third variable (social media engagement), termed here as the moderator. In line with this position advanced by the contingency theory, which addresses fit as a moderator, this study posits that the fit between social media engagement as a contingent factor is a prerequisite for high customer performance. That is because social media engagement generates precise effect relationships that produce improved branding efficiency and overall performance (Aydin, 2020). The implication of the contingency theory is by leveraging social media platforms effectively, banks can build stronger brand awareness, foster positive customer interactions, and ultimately improve customer performance metrics, such as loyalty, satisfaction, and advocacy.

The conceptual relevance of social media engagement suggests that it provides an extensive reach, allowing banks to connect with existing and potential customers on a global scale. By creating and sharing engaging content that reflects the bank's values, services, and commitment to customers, the brand gains visibility and awareness among the target audience. Consistent branding across social media channels reinforces the bank's identity and message, making it more memorable to customers. Also, social media enables direct and real-time communication between banks and customers. Customers can ask questions, provide feedback, and share their experiences, while the bank can promptly respond, addressing concerns and resolving issues. This two-way communication fosters a sense of transparency, trust, and approachability, which are vital for building a positive brand image. Similarly, social media platforms collect valuable data on user demographics, interests, and behaviors. Banks can leverage this information to personalize their content and offers based on individual customer preferences and needs. Tailoring messages to specific customer segments enhance relevance and engagement, leading to better customer performance outcomes (Adeniran et al., 2024).

Also, by encouraging customers to share their positive experiences through user-generated content can be a powerful branding tool. Testimonials, reviews, and success stories from satisfied customers create social proof and advocate for the bank's services. This user-generated content influences potential customers and bolsters brand reputation, leading to improved customer performance. Social media allows banks to showcase their innovative products and services. By highlighting unique offerings, special promotions, and limited-time deals, banks can attract new customers and encourage existing ones to explore additional services. Effective promotion through social media can lead to increased customer adoption and retention. A scholar posits that social media engagement can acts as a moderator in the relationship between bank branding activities and customer performance. When banks invest in

branding activities and concurrently focus on engaging customers through social media, the positive impact on customer perception and loyalty is amplified. Social media engagement intensifies the effects of branding initiatives, leading to enhanced customer performance indicators, such as customer satisfaction, retention, and advocacy (Rachbini, 2023).

### 3. Methodology

#### *Research Philosophy, Approach, & Design*

This study adopts a positivist research philosophy to examine the effect of branding on the customer loyalty of Deposit Money Banks (DMBs) in Lagos State, Nigeria. Positivism assumes that reality is objective and can be observed, measured, and analyzed through scientific inquiry. The justification for adopting this philosophy lies in its emphasis on empirical data, which supports the derivation of reliable, replicable, and objective conclusions about observable phenomena (Onamusi, & Olukolu, 2023). Accordingly, the study employs a quantitative research approach to measure and analyze the relationships among variables numerically. This approach is appropriate because it enables statistical examination of causal and correlational relationships while ensuring reliability and validity of findings through quantifiable evidence (Umukoro et al., 2023). A cross-sectional survey design is adopted to examine the relationship between branding and customer performance at a specific point in time. This design aligns with the positivist paradigm and the quantitative methodology, as it facilitates the collection of standardized data from a large sample efficiently and cost-effectively. Cross-sectional surveys have proven effective in investigating branding–performance relationships in marketing studies (Asikhia et al., 2020; Tijani et al., 2021).

#### *Population and Sampling Technique*

The study's target population comprises customers of Deposit Money Banks (DMBs) in Lagos State, Nigeria. According to the Nigeria Inter-Bank Settlement System (NIBSS, 2022), there are approximately 56.5 million DMB customers with active Bank Verification Numbers (BVNs) nationwide. However, due to the unavailability of precise figures for Lagos State from regulatory institutions such as the Central Bank of Nigeria (CBN) and NIBSS, the population for this study is considered unknown yet homogeneous, as DMB customers share similar transactional experiences and service expectations. The sample size was determined using Cochran's formula for an infinite

population, resulting in 600 respondents. To account for potential non-responses and incomplete questionnaires, an additional 20% (120 respondents) was added, yielding a final sample size of 720 participants. A purposive sampling technique was employed to select participants who met specific inclusion criteria: Must be an adult (18 years or older); Must possess at least one active bank account; and Must reside in Lagos State. This non-probability sampling method is suitable because it allows the selection of respondents based on characteristics relevant to the research objectives, thereby ensuring meaningful representation of the target population.

#### *Instrument, Measurement, & Pilot Study Analysis*

Data were collected using a structured, closed-ended questionnaire, chosen for its efficiency in gathering standardized data from a large number of respondents within a short time frame. The questionnaire was adapted from validated scales in prior studies (Hollebeek et al. 2022; Mogaji et al. 2021; Onamusi & Ayo, 2021). Responses were measured using a six-point Likert scale, ranging from 6 (Strongly Agree) to 1 (Strongly Disagree). This even-numbered scale avoids central tendency bias and enables more decisive responses. The instrument was divided into sections corresponding to the study variables: Branding dimensions (brand identity, image, positioning, and reputation), Customer performance dimensions (loyalty, preference, satisfaction, and repeat patronage), and Social media engagement (interactive, responsive, and content-related engagement indicators).

A pilot study was conducted among DMB customers in Ibadan, chosen due to their similar demographic and behavioral characteristics to Lagos customers. A total of 72 questionnaires (10% of the main sample) were distributed using convenience sampling; 61 valid responses (an 84.72% response rate) were analyzed after data cleaning. Face validity was established through expert reviews by academic faculty at Lead City University, Ibadan, feedback from banking industry practitioners, and input from the research supervisor. Necessary modifications were made based on these reviews. To statistically confirm construct validity, Confirmatory Factor Analysis (CFA) was performed using SmartPLS 4.0, to compute the Average Variance Extracted (AVE). Convergent validity was confirmed as all AVE values exceeded the recommended 0.50 threshold, as shown in Table 1.

Table 1:

## Summary of Pilot Test and Construct Validity

| Variable                | Items Before Pilot | Items Retained | AVE   | Remark   |
|-------------------------|--------------------|----------------|-------|----------|
| Brand Identity          | 10                 | 8              | 0.787 | Reliable |
| Brand Image             | 9                  | 6              | 0.681 | Reliable |
| Brand Positioning       | 9                  | 6              | 0.644 | Reliable |
| Brand Reputation        | 9                  | 6              | 0.699 | Reliable |
| Customer Loyalty        | 7                  | 5              | 0.768 | Reliable |
| Customer Preference     | 7                  | 5              | 0.710 | Reliable |
| Repeat Patronage        | 7                  | 5              | 0.705 | Reliable |
| Customer Satisfaction   | 7                  | 5              | 0.649 | Reliable |
| Social Media Engagement | 10                 | 8              | 0.697 | Reliable |

Source: Computed from Pilot Study (2025)

To test discriminant validity, the Heterotrait–Monotrait (HTMT) ratio was applied. All HTMT val-

ues were below the 0.90 threshold, confirming discriminant validity across constructs (Henseler et al., 2015).

Table 2:

## Discriminant Validity using Heterotrait-Monotrait Ratio (HTMT)

| Construct                 | BIM  | BID  | BRP  | BRR  | CUL  | CUP  | CRP  | CUS   | SME |
|---------------------------|------|------|------|------|------|------|------|-------|-----|
| Brand identity            |      |      |      |      |      |      |      |       |     |
| Brand image               | 0.05 |      |      |      |      |      |      |       |     |
| Brand positioning         | 0.58 | 0.22 |      |      |      |      |      |       |     |
| Brand reputation          | 0.18 | 0.28 | 0.27 |      |      |      |      |       |     |
| Customer loyalty          | 0.12 | 0.30 | 0.18 | 0.11 |      |      |      |       |     |
| Customer preference       | 0.15 | 0.19 | 0.32 | 0.13 | 0.24 |      |      |       |     |
| Customer repeat patronage | 0.51 | 0.15 | 0.32 | 0.04 | 0.02 | 0.18 |      |       |     |
| Customer satisfaction     | 0.05 | 0.03 | 0.08 | 0.12 | 0.16 | 0.06 | 0.16 |       |     |
| Social media engagement   | 0.14 | 0.34 | 0.28 | 0.10 | 0.01 | 0.04 | 0.15 | 0.285 |     |

Source: Computed from Pilot study via SmartPLS version 4.0, 2025

These results collectively confirm construct validity, indicating that the measurement items effectively capture the intended theoretical constructs. Further-

more, reliability was established using Composite Reliability (CR) and Cronbach's Alpha (CA) coefficients, both exceeding the 0.70 benchmark (Hair et al., 2021).

Table 3:

## Reliability Statistics

| Variable                | Composite Reliability | Cronbach's Alpha |
|-------------------------|-----------------------|------------------|
| Brand Identity          | 0.917                 | 0.768            |
| Brand Image             | 0.721                 | 0.703            |
| Brand Positioning       | 0.692                 | 0.608            |
| Brand Reputation        | 0.735                 | 0.605            |
| Customer Loyalty        | 0.728                 | 0.698            |
| Customer Preference     | 0.791                 | 0.786            |
| Repeat Patronage        | 0.742                 | 0.703            |
| Customer Satisfaction   | 0.741                 | 0.763            |
| Social Media Engagement | 0.733                 | 0.720            |

Source: Computed from Pilot Study (2025)

These results indicate that all constructs exhibit satisfactory internal consistency and measurement reliability.

### Data Collection Procedure & Analysis Technique

Given that both branding and customer loyalty are customer-oriented phenomena, data were collected directly from bank customers rather than employees. The structured questionnaire was self-administered to the 720 selected respondents in Lagos State through physical distribution and electronic links to enhance response efficiency. Participation was voluntary, and re-

spondents were assured of anonymity and confidentiality. Ethical standards were upheld following institutional research ethics guidelines. Data were analyzed using descriptive and inferential statistics to test the study hypotheses. Specifically, Partial Least Squares–Structural Equation Modeling (PLS-SEM) was employed using SmartPLS 4.0. The choice of PLS-SEM was based on its robustness in handling complex models involving latent constructs, its suitability for exploratory studies, and its ability to estimate both measurement and structural models simultaneously (Hair et al., 2021). This technique also allows for path analysis, mediation, and moderation testing critical for assessing the

moderating effect of social media engagement on the branding–customer performance relationship. Results were interpreted based on the significance level of  $p \leq 0.05$ , in line with conventional statistical standards. Compared to traditional regression analysis using SPSS, PLS-SEM provides more comprehensive insights into latent relationships, model fit, and construct reliability. Thus, it offers a rigorous and integrated analytical approach consistent with the study's positivist orientation.

#### 4. Results and Discussion of Findings

Table 4:

| Demographic Characteristic of Respondents |                    |           |            |
|-------------------------------------------|--------------------|-----------|------------|
| Variables                                 | Category           | Frequency | Percentage |
| Gender                                    | Male               | 262       | 48.9%      |
|                                           | Female             | 351       | 51.1%      |
| Age                                       | 21-30 years        | 287       | 41.8%      |
|                                           | 31-40 years        | 175       | 25.5%      |
|                                           | 41-50 years        | 148       | 21.5%      |
|                                           | 51-60 years        | 70        | 10.2%      |
|                                           | 61-65 years        | 7         | 1.0%       |
|                                           | Others             | 112       | 16.3%      |
| Educational qualifications                | ND/NCE             | 252       | 36.7%      |
|                                           | B.Sc/BA/HND        | 260       | 37.8%      |
|                                           | PGD/MBA/MSc/MA     | 14        | 2.0%       |
|                                           | MPhil              | 42        | 6.1%       |
|                                           | PhD                | 7         | 1.0%       |
|                                           | Others             | 133       | 19.4%      |
| Years of experience                       | 0-5 years          | 217       | 31.6%      |
|                                           | 6-10 years         | 98        | 14.3%      |
|                                           | 11-15 years        | 119       | 17.3%      |
|                                           | 16-20 years        | 120       | 17.5%      |
|                                           | 21 years and above |           |            |

Source: Researcher's Field Survey Results, 2025

This section consists of background and respondent's information that describes basic characteristics such as gender of the respondent, age of the respondent and faculty. The Table 1 presents the demographic and personal profile of respondents used for this study. Demographic and personal profile of respondents as shown in Table 1: Profile of gender indicated that 336 respondents representing 48.9% were male while 351 respondents representing 51.1% were females, indicating that most of the respondents were female. Demographic and personal profile of respondents as shown in Table 1 by age revealed that 287 respondents representing 41.8% were between age 21-30 years, 175 respondents representing 25.5% were between 31-40 years, 148 respondents representing 21.5% were between 41-50 years, 70 respondents representing 10.2% were between 51-60 years, 7 respondents representing 1.0% were between 61-65 years, indicating that there were more respondents within the age 21-30 years. Furthermore, 112 respondents representing 16.3% indicated that they had ND/NCE, 252 respondents representing 36.7% had B.Sc/BA/HND, 260 respondents representing 37.8% had PGD/MBA/MSc/MA, 14 respondents representing 2.0% had MPhil, 42 respondents representing 6.1% had PhD and 7 respondents representing 1.0% had Others. Also, 133 respondents representing 19.4% indicated to have experience for 0-5 years, 217

respondents representing 31.6% have experience between 6-10 years, 98 respondents representing 14.3% have experience between 11-15 years, 119 respondents representing 17.3% have experience between 16-20 years and 120 respondents representing 17.5% have experience between 21 year and above.

**H<sub>01</sub>:** Social media engagement has no significant moderating effect on the interaction between branding and customer performance of selected Deposit Money Banks in Lagos State, Nigeria

To test the null hypothesis seven, PLS-Structural Equation Modelling (PLS-SEM) was adopted using the SmartPLS statistical platform version 4.0. The independent variable is branding, customer performance constitutes the dependent variable while social media engagement is the moderating variable. Data from six hundred and eighty-seven (687) respondents were collated for the analysis. The result of the PLS-SEM is presented in three model (see figure 1, 2, & 3) and a Table (see table 2). Figure one shows the path analysis, figure two shows the t values which confirm the significance of the path analysis and figure three shows Q<sup>2</sup> which confirms the predictive relevance of the structural model (t value above 1.96 and Q<sup>2</sup> above zero confirm a statistically significant effect and that the structural model specified is relevance). Each model comprised

of outer model which shows the factor loadings (correlation) of each item in relation to the latent variable and the inner model termed the structural model (predictive

model) which explains the interactions between branding and customer performance in this study. The table 2 provides a tabular representation of the information in figure 1, 2, and 3.

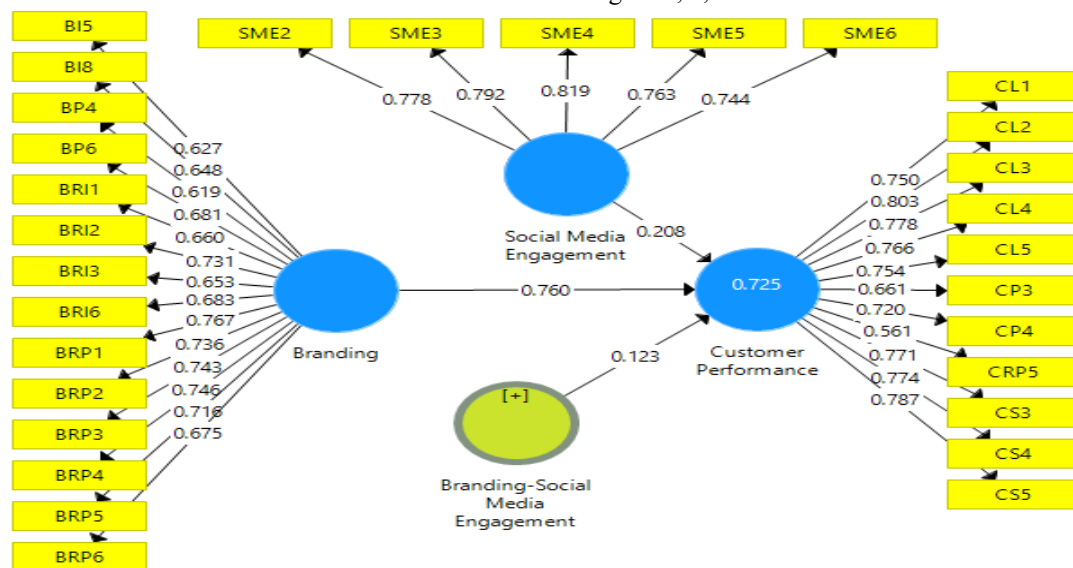


Figure 1: Measurement Model for Hypothesis One  
Source: Researcher's Computation via SmartPLS V4.0, 2025

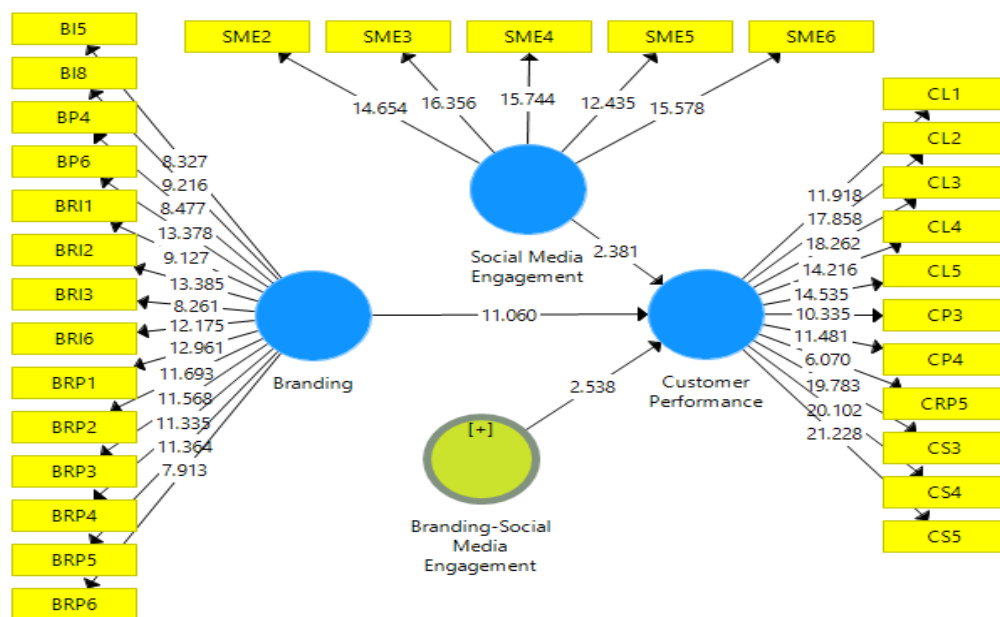


Figure 2. Structural Model for Hypothesis One  
Source: Researcher's Computation via SmartPLS V4.0, 2025



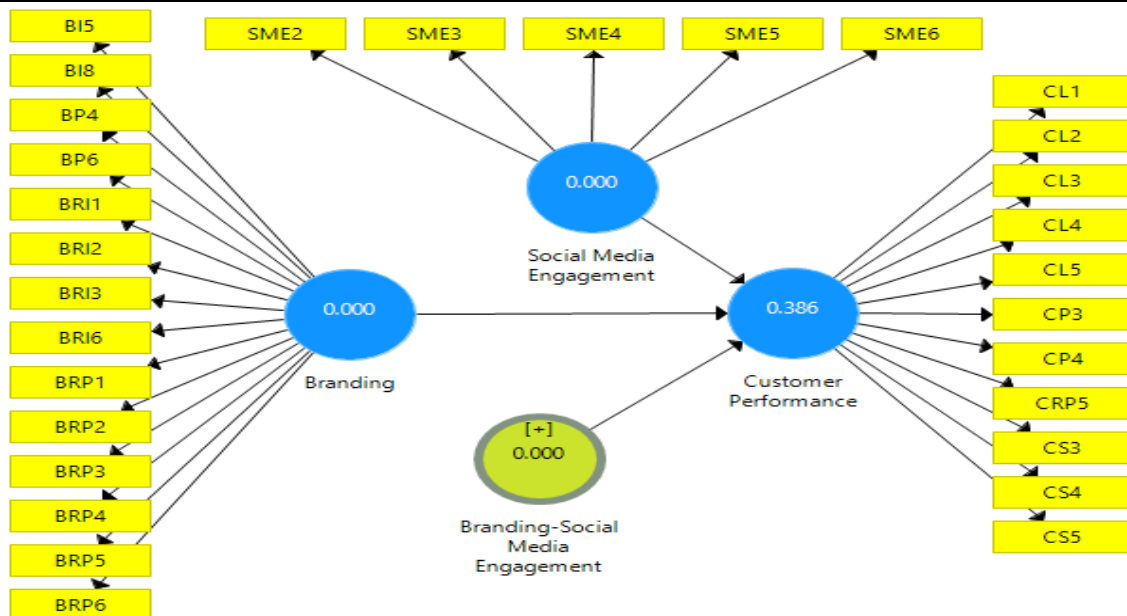


Figure 3. Q2 Statistics for Hypothesis One  
Source: Researcher's Computation via SmartPLS V4.0, 2025

Table 5:  
Summary of PLS-SEM Analysis for Moderating Effect of Social Media Engagement on the Interaction between Branding and Customer Performance of DMBs in Lagos State, Nigeria

| Path Description                                          | Original sample (o)<br>Unstandardized Beta | Sample<br>Mean | Standard<br>Deviation | T      | Sig.  | Q <sup>2</sup> |
|-----------------------------------------------------------|--------------------------------------------|----------------|-----------------------|--------|-------|----------------|
| Branding → Customer performance                           | 0.760                                      | 0.759          | 0.069                 | 11.060 | 0.000 | 0.386          |
| Social media engagement → Customer performance            | 0.280                                      | 0.216          | 0.049                 | 2.538  | 0.011 |                |
| Interaction-term Moderating Effect → Customer performance | 0.123                                      | 0.126          | 0.087                 | 2.381  | 0.018 |                |

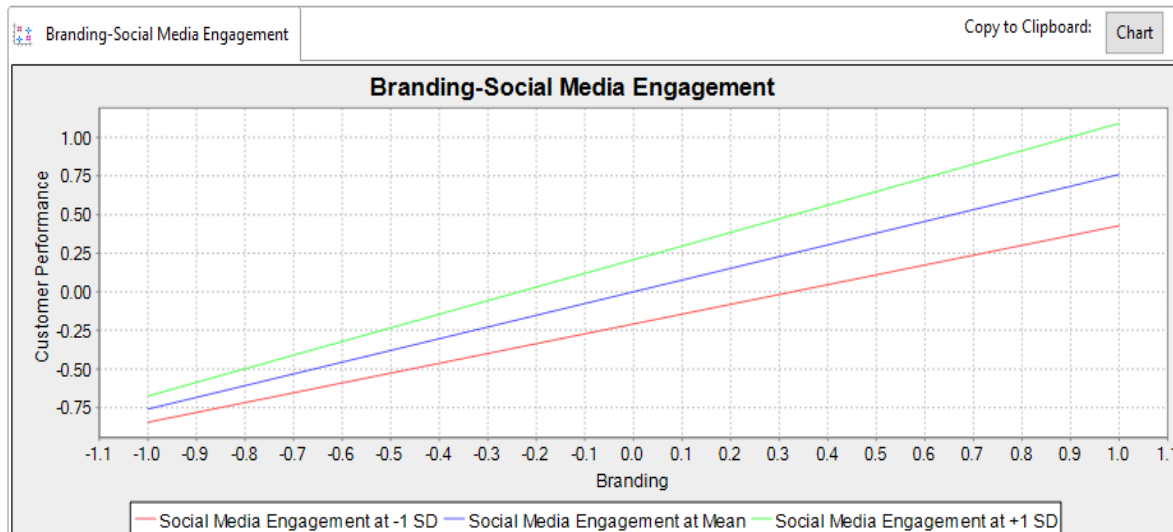
Source: Researcher's Result via SmartPLS Version 4.0, 2025

Figure 1, 2 and 3 presents the results of PLS-SEM analysis for the moderating effect of social media engagement on the interaction between branding and customer performance of selected DMBs in Lagos State, Nigeria. To establish the moderating effect in a PLS-SEM warrants the creation of a new variable termed branding\*social media engagement. This interaction term's influence is examined on the dependent variable (customer performance) and a significant moderating effect is established if the coefficient of interaction term has a p value less than 0.05. It is noteworthy that in a moderation PLS-SEM analysis, emphasis is on the moderating path result and with less attention to Adj R<sup>2</sup>

or the R<sup>2</sup> coefficient found in SPSS output for moderation analysis.

From the result in figure 1, 2, and 3, it is observed that the interaction term of branding\*social media engagement has a path coefficient of determination value of 0.123. This suggest that the introduction of social media engagement has enhance the effect branding has on customer performance by 0.123 and this moderating effect is positive and statistically significant at p-value = 0.018. In addition, the SmartPLS provided the Simple Slope Analysis (SSA) which provide additional evidence to reinforce the presence or absence of a moderating effect.

## Simple Slope Analysis



## Simple Slope Analysis

Figure 4: Simple Slope Analysis for the moderating effect of social media engagement

Source: Researcher's Computation via SmartPLS V4.0, 2025

From Figure 4, the red line shows low social media engagement at one standard deviation below the mean, the blue line shows social media engagement at mean which indicates regular effect without the moderation effect and the green shows high social media engagement at one standard deviation above the mean and it reflects the moderation effect. Hence, the green line which is above the blue line suggest that DMBs involved in making high level of social media engagement enhance the branding-performance linkage. It is on the strength of the moderated analysis result ( $\beta = 0.123$ ;  $p < 0.018$ ,  $Q^2 = 0.386$ ) and the Simple Slope Analysis obtained that this study conclude that social media engagement has a positive and significant moderating effect on the interaction between branding and DMBs performance in Lagos State, Nigeria. Hence, the study accept the alternative hypothesis one ( $H_{01}$ ) which states that social media engagement has positive and significant moderating effect on the interaction between branding and customer performance of selected DMBs in Lagos State, Nigeria.

## 5. Discussion, Conclusion, Recommendations, & Future studies

The findings of this study contribute new empirical evidence to marketing and banking research by demonstrating that social media engagement significantly moderates the relationship between branding and customer performance. Existing literature provides limited empirical validation of this interaction, suggesting that this study is among the first to explore the moderating influence of social media engagement within the context of Deposit Money Banks (DMBs) in Lagos State, Nigeria.

Drawing on the Contingency Theory of Fit, this study supports the argument of Naidu et al. (2023) and Onamusi (2021), who posited that when two variables interact to predict a third, an underlying contingency relationship exists. Applying this theoretical logic, the

study confirms that the effect of branding (independent variable) on customer performance (dependent variable) depends on the level of social media engagement (moderator). In other words, the strength of the branding-performance relationship is contingent upon how effectively DMBs engage customers through social media platforms.

The results indicate that when banks actively leverage social media platforms to interact with customers, branding activities such as identity, image, positioning, and reputation produce stronger and more positive effects on customer outcomes, including satisfaction, loyalty, preference, and repeat patronage. Conversely, low levels of social media engagement weaken these relationships, resulting in diminished brand effectiveness and weaker customer connections. This finding aligns with Aydin (2020), who argued that the fit between organizational strategy and contextual factors enhances performance outcomes, especially when digital tools are used to strengthen brand and customer relationships. From a conceptual standpoint, social media engagement enhances branding efficiency through multiple pathways. First, it provides extensive reach, enabling banks to connect with customers on a global scale (Onamusi, 2021). Through creative and consistent content sharing, banks can reinforce their brand identity, communicate value propositions, and maintain visibility among diverse audiences. Second, social media facilitates two-way communication, allowing customers to express feedback, ask questions, and share experiences, while banks respond promptly to inquiries and concerns. This interaction promotes transparency, trust, and relational bonding, which are essential for brand credibility.

Furthermore, social media engagement enables personalization which means, banks can analyze customer data on demographics, interests, and behaviors to tailor content, offers, and experiences to specific mar-

ket segments (Rane et al., 2023). Personalized engagement enhances customer satisfaction and fosters emotional connections that drive loyalty and advocacy. Additionally, social media platforms encourage user-generated content such as testimonials, reviews, and endorsements, which act as digital word-of-mouth marketing and social proof, further amplifying brand reputation and performance outcomes. This study's results also align with Rachbini (2023), who found that social media engagement intensifies the effect of branding initiatives on customer performance. When banks combine strong branding efforts with active online engagement, customers perceive higher service reliability, emotional connection, and trust. This synergy produces greater satisfaction, retention, and advocacy which are key dimensions of customer performance.

From a theoretical perspective, the findings corroborate the Dynamic Capability Theory (DCT), which asserts that firms must continuously build and reconfigure internal and external competencies to respond effectively to environmental changes (Teece et al., 1997; Teece, 2019). In this study, social media engagement operates as a dynamic capability, enabling DMBs to adapt their branding strategies to evolving customer expectations and digital interaction trends. By leveraging digital platforms, DMBs can sense customer needs, seize engagement opportunities, and transform their service delivery to sustain a competitive advantage. Thus, the combined insights from contingency theory and DCT illustrate that customer performance improvements result not only from branding as a resource but also from social media engagement as a capability that dynamically aligns brand communication with environmental realities.

Based on the empirical findings, the study concludes that branding constructs including brand image, brand identity, brand positioning, and brand reputation have a positive and statistically significant effect on customer performance among Deposit Money Banks in Lagos State. Strong branding enhances customer satisfaction, trust, loyalty, and repeat patronage, all of which are essential to sustaining competitiveness in the Nigerian financial industry. The study establishes that social media engagement significantly moderates the relationship between branding and customer performance. The moderating effect reveals that higher levels of customer interaction on social media amplify the positive influence of branding on customer outcomes, confirming the theoretical logic of fit as posited by contingency theorists. Therefore, strategic alignment between a bank's branding initiatives and its digital engagement activities is a critical success factor in achieving superior customer performance. From a theoretical lens, this finding reinforces Dynamic Capability Theory, emphasizing that social media engagement functions as a dynamic organizational capability that enables banks to sense customer preferences, adapt communication strategies, and co-create value with customers in real time.

In light of the findings and theoretical implications, this study recommends that Deposit Money Banks should embed social media engagement into

their branding strategies as a dynamic capability. Active interaction, prompt responses, and real-time updates should form part of daily brand communication practices. Also, Banks should develop engaging and personalized social media content that reflects their brand values and directly addresses customer needs. Leveraging analytics from social platforms can help tailor communications that resonate with specific customer segments. Customer-facing employees and digital communication teams should be trained to manage social media interactions professionally and empathetically, ensuring consistent brand tone and customer satisfaction. Finally, Banks should adopt data-driven monitoring systems to evaluate the impact of social media engagement on customer metrics such as loyalty, satisfaction, and retention. Insights from these evaluations can guide continuous improvement and innovation in branding strategies.

Theoretically, this study contributes to marketing and strategic management literature by integrating Contingency Theory and Dynamic Capability Theory to explain how social media engagement moderates the branding–customer performance relationship. It provides empirical evidence of how digital engagement functions as a contextual fit and dynamic capability that strengthens brand outcomes. Practically, the study offers actionable insights for bank managers and marketing strategists. It emphasizes the need for digital alignment between brand identity and customer interaction to achieve sustained performance improvements.

Although this study makes substantial theoretical and empirical contributions to understanding how social media engagement moderates the relationship between branding and customer performance, it is not without limitations. Acknowledging these limitations provides perspective on the scope of the findings and offers valuable guidance for future research.

The first limitation relates to the geographical scope of the study. The research focused exclusively on Deposit Money Banks (DMBs) in Lagos State, Nigeria. While Lagos is the nation's commercial capital and a representative setting for digital banking and customer engagement, it may not fully capture the diversity of experiences and behaviors of bank customers in other regions of Nigeria. Customers in semi-urban or rural areas may differ in their levels of digital exposure, banking habits, and engagement with social media. Consequently, generalizing the findings beyond Lagos should be approached with caution. Future research could therefore expand the geographical coverage to include multiple regions across Nigeria or even conduct cross-national comparative studies within sub-Saharan Africa. Such comparative approaches would help determine whether contextual and cultural variations influence the moderating role of social media engagement in the branding–customer performance relationship.

Another limitation concerns the research design. The study employed a cross-sectional survey approach, which captures data at a single point in time. Although this design is cost-effective and efficient, it restricts the ability to make strong causal inferences. Branding strategies and customer performance outcomes are dynamic phenomena that evolve over time in response to

changes in technology, competition, and consumer behavior. A longitudinal design would help in understanding how variations in branding strategies and digital engagement affect customer loyalty and satisfaction over an extended period. Future studies may therefore adopt longitudinal or panel designs to provide stronger evidence of causality and track the temporal effects of branding and social media engagement.

The reliance on self-reported data represents another limitation. Because data were obtained through structured questionnaires, the findings are subject to common method bias and social desirability effects. Respondents may have provided answers they perceived as socially acceptable rather than those that accurately reflect their true experiences. Future studies could mitigate this limitation by adopting a mixed-method approach that combines quantitative surveys with qualitative techniques such as interviews, focus groups, or sentiment analysis of social media content. Such triangulation would provide a richer understanding of customer perceptions and offer deeper insights into how customers emotionally and cognitively interact with bank brands in the digital space. While the study concentrated on social media engagement as the moderating variable, other contextual factors may also influence the relationship between branding and customer performance. Variables such as perceived service quality, brand trust, and customer experience management could moderate or mediate the relationship in meaningful ways. Future research could incorporate these additional constructs to develop a more comprehensive model of customer performance determinants within the financial services industry.

The study's sampling approach also introduces a degree of limitation. Purposive sampling was used to ensure that only relevant participants active DMB customers resident in Lagos were included. While this method ensures the selection of knowledgeable respondents, it may reduce the generalizability of results. Future studies might consider employing probability-based sampling techniques to ensure more representative samples and enhance external validity. Despite these limitations, this study offers valuable theoretical and practical insights as it demonstrated how social media engagement acts as a dynamic capability that strengthens the link between branding and customer performance.

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# TECHNICAL SCIENCES

## SOLUTIONS AND PERSPECTIVES ON ELECTRICAL ENERGY STORAGE IN ROMANIA'S POWER SYSTEM

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### Abstract

Electrical energy storage is becoming a strategic element in Romania's transition toward an energy system based on renewable sources. This paper analyzes the current state of storage capacities, major ongoing projects, and prospects for expansion up to 2030. It presents large-scale battery storage solutions and pumped-storage hydropower systems, as well as the main challenges related to costs, infrastructure, and regulations. The results indicate significant yet insufficient progress compared to the estimated national demand. Accelerating investments and modernizing the legislative framework are essential for ensuring grid stability and Romania's energy security.

**Keywords:** electrical energy storage, large-capacity batteries, pumped-storage hydropower

### 1. Introduction

Electrical energy storage has become a central topic in the context of the transition toward renewable energy sources. In Romania, this issue is gaining increasing importance as the country aims to meet the climate-neutrality objectives established at the level of the European Union [1].

Romania benefits from a diversified energy mix, based on nuclear, hydropower, coal, natural gas, and renewable sources. In recent years, there has been a significant increase in the installed capacities of wind and

photovoltaic energy; however, these sources are highly variable [2].

Such fluctuations create the need for energy storage to balance supply and demand, especially during periods when renewable generation exceeds consumption. Without efficient storage solutions, Romania risks facing challenges in maintaining the stability of the national electricity grid and in ensuring a constant energy supply to residential and industrial consumers [3].

Table 1

Electricity consumption, imports and exports 2024/2025

| Indicator                              | 2024                                                                                                    | 2025 (partial)                                                                     | Source          |
|----------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-----------------|
| Final electricity consumption (annual) | ~50.5 TWh (2024)                                                                                        | First 7 months of 2025: ~29.37 TWh (slightly higher than 2024 for the same period) | INS Reports [4] |
| Net imports                            | Increased imports in 2024; in 2025 imports remain significant during periods of low domestic production | 2024: record imports in certain months; 2025: high imports during months I–VII     | INS Reports [4] |
| Exports                                | Lower in 2024 compared to 2023 (INS 2024 data)                                                          | 2025: reduced during periods of internal deficit (provisional)                     | INS Reports [4] |

According to data available by mid-2025, Romania had an installed battery storage capacity of approximately 240.7 MW and an energy storage capacity of around 404.9 MWh [5]. A World Bank report estimates that Romania could reach **4 GW** of battery storage capacity by **2030** and over **11 GW** by **2050** [6]. Analysis by Transelectrica indicates that, by 2030, the country will need between **2–4 GW** of power and **10–20 GWh** of stored energy to support the transition toward a system with a major share of renewables [7].

Given these data, it is evident that Romania has an urgent need for new electricity storage capacities within its national energy system. The pressure is increasing as aging coal-fired plants are gradually decommissioned [8] and replaced with renewable energy sources. Until recently, Romania relied almost exclusively on adjusting hydropower output during peak

hours; however, periods of drought, heat, or low wind have shown that in many scenarios [9], the system can no longer cope due to insufficient storage capacity. The Romanian Ministry of Energy has therefore declared energy storage a “zero-priority” within the national energy system, similar to initiatives in other European countries [10].

### 2. Energy Storage Solutions Applicable in Romania

In Romania, the main technological solutions for electrical energy storage are **large-capacity battery storage systems** and **pumped-storage hydropower (PSH)** facilities.

#### 2.1 Large-Capacity Battery Storage

At present, battery energy storage in Romania is still in a developmental stage. At the beginning of 2024,



there was only one installation integrated into the national energy system, with a capacity of **7 MW** [11]. In addition, several establishment authorizations were issued by the **National Energy Regulatory Authority (ANRE)** for future projects associated with intermittent renewable generation plants. Major international players have also expressed interest in entering the Romanian storage market.

For instance, in **April 2024**, the company **Monsson** commissioned Romania's largest battery energy storage installation — **24 MWh (6 MW × 4 h)** —

as part of a hybrid photovoltaic–wind–battery project located within a wind farm in **Constanța**. This storage unit represents only the first stage of a broader project expected to reach a total capacity of **216 MWh**, using **locally manufactured batteries** produced by **Prime Batteries Technology**.

## 2.2 Battery Storage Projects

Several major battery energy storage projects are currently under development or construction in Romania.

Table 2

Battery Energy Storage Projects in Romania: Capacity (MW/MWh), Status, and Funding Source

| Project / Developer                                                         | Installed Power (MW) | Capacity (MWh)       | Status                                                  | Funding Source / Remarks                                            |
|-----------------------------------------------------------------------------|----------------------|----------------------|---------------------------------------------------------|---------------------------------------------------------------------|
| <b>Nova Power &amp; Gas – Florești, Cluj</b>                                | 200                  | 400                  | Under construction, expected operational by end of 2025 | Private investment; expected to double national capacity            |
| <b>HELLENiQ Renewables Romania – Vaslui</b>                                 | 186                  | 186                  | Ready-to-Build (RTB)                                    | Acquisition of a portfolio; storage component part of wind projects |
| <b>Simtel / Energy Capital Group – Iaz, Caraș-Severin</b>                   | ≈98.6                | ~196                 | EPC contract signed (2025)                              | Partial PNRR grant (≥ RON 50 million) for battery system            |
| <b>Renovatio Trading – Toplița, Harghita</b>                                | ≈30                  | 60.96                | Under development (completion by 2026)                  | PNRR grant eligibility ~RON 111.5 million; sub-component I.4        |
| <b>Monsson / Prime Batteries Technology – Constanța (Mireasa Wind Park)</b> | 6 (Phase 1)          | 24 (Phase 1)         | Operational (2024) – Phase 1 of 3                       | Hybrid wind–solar–battery project; domestic battery production      |
| <b>Electrica S.A. Group – Fântânele, Mureș</b>                              | 35                   | 70 (tender launched) | Procurement stage (2025)                                | Storage system + 110 kV substation; PNRR scheme component           |

Furthermore, **Hidroelectrica** announced plans to install a **64 MW / 256 MWh** battery project at the **Iron Gates II (Porțile de Fier II)** hydropower plant, with an estimated investment of **€61.2 million**, as well as a **€16**

**million** investment in a **36 MW / 72 MWh** battery system at the **Crucea Nord** wind farm (108 MW).

## 2.3 Evolution of Installed Battery Storage Capacity in Romania (2025)

Table 3

Evolution of Installed Battery Storage Capacity in Romania – 2025

| Date / Reference        | Installed Power (MW) | Energy Capacity (MWh) | Remarks / Source                                                                         |
|-------------------------|----------------------|-----------------------|------------------------------------------------------------------------------------------|
| 01.01.2025              | 137                  | 269                   | Situation reported by Transelectrica at the beginning of 2025                            |
| 01.04.2025              | 235                  | 399                   | Data provided by Transelectrica                                                          |
| 01.09.2025              | 249                  | 434                   | Situation reported by Transelectrica                                                     |
| Estimated (end of 2025) | ~400–500             | ~1,000–1,200          | Estimate based on projects under development and public announcements – indicative value |

## 2.4 Pumped-Storage Hydropower (PSH)

On the lower **Olt River**, there are several low-head hydropower plants equipped with reversible turbines; however, these have so far operated predominantly in turbine mode, not in pumping mode.

The **Lotru hydropower complex** is currently the **only facility in Romania equipped for both generation and pumping operation** (Figure 1). It is the most complex development on Romania's inland rivers, based on a design that concentrates flows and hydraulic

heads. The scheme collects waters from the **Lotru River basin** and neighboring basins, directing them gravitationally and by pumping toward **Vidra Lake**, which serves as the main reservoir [12].

The Lotru complex consists of the **Lotru–Ciunget Hydropower Plant (HPP)**, an underground facility with installed power of **510 MW**,  $Q_{inst} = 80 \text{ m}^3/\text{s}$ , and **gross head = 809 m**, together with the **Petrimanu, Jidoia, and Lotru Aval** pumping stations.

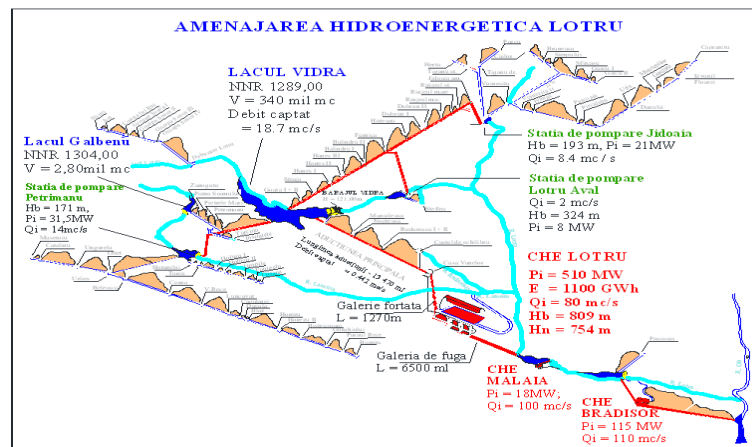


Figure 1. Diagram of the Lotru Hydropower Complex – [12]

Several potential sites for the construction of **pumped-storage hydropower plants (PSH plants)** have also been identified (Figure 2, red dots).

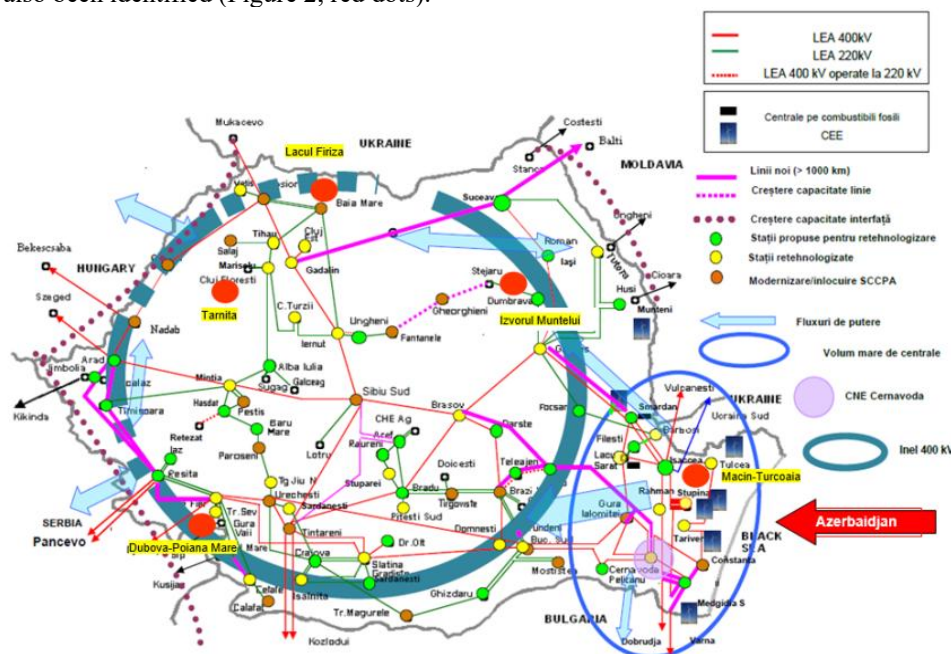


Figure 2. Potential locations for pumped-storage hydropower plants – [12]

The main proposed projects include:

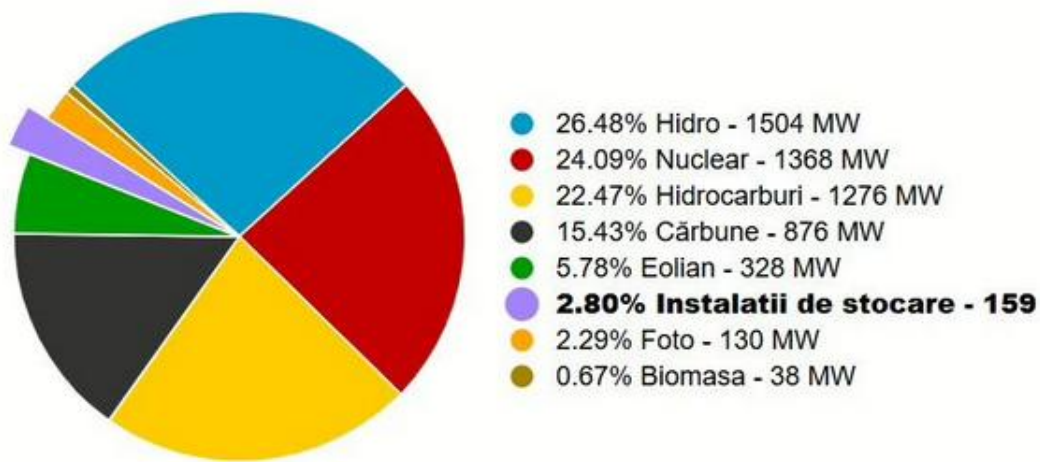
- **Tarnița-Lăpușești PSH** – Specification: 1,000 MW; reservoir capacity 14 million m³. Objectives: balancing the central and western grid areas; controlling power flow to/from Hungary.
- **Măcin-Turcoaia PSH** – Specification: 1,000 MW; lower reservoir – Danube River (no need for new lower reservoir works), upper reservoir 25 million m³, ideally located in a former stone quarry. Objectives: reducing renewable generation congestion in Dobrogea (wind + nuclear); managing energy exchange with Bulgaria and Azerbaijan.
- **Firiza Lake PSH and Izvorul Muntelui PSH** – Specifications: possible options of 500 MW or 1,000

MW (detailed analysis required). Objectives: controlling energy flow to/from Ukraine and Moldova.

- **Dubova-Poiana Mare PSH** – Specification: 750 MW; lower reservoir – Iron Gates I accumulation lake; upper reservoir – Sura Mare or Poiana Mare plateau; useful storage volume: 13 million m³. Objectives: regulating energy flows with Serbia, Hungary, and partially Bulgaria.

Such facilities could play a **significant role in balancing the national grid during periods of renewable surplus.**

According to Transelectrica data from the morning of September 29, 2025, almost **two-thirds of the installed storage capacity** was briefly used to inject electricity into the grid.



**Total 5683 MW - Productia in 29-09-2025 ora 08:55:27**

Figure 3. Electricity generation by source on the morning of 29.09.2025 [13]

As shown in Figure 3, at the morning consumption peak, about **2.8% of all electricity produced and injected into Romania's grid** came from storage installations — energy previously stored from the grid during low-price hours and released back during peak demand.

### 3. Projects and Initiatives in the Field of Energy Storage in Romania

Over the past three years, several **national programs and funding schemes** have been launched to stimulate investment in energy storage infrastructure.

#### 3.1 National Recovery and Resilience Plan (PNRR) Funding

A key component of Romania's energy transition is represented by the **PNRR (National Recovery and Resilience Plan)**, through which several sub-components target the development of storage capacities. Under **Component C.6 – Energy, Sub-component I.4 – Renewable energy sources and energy storage**, Romania allocated substantial non-reimbursable funds for the installation of **new electricity storage capacities** totaling approximately **240 MWh** by 2026.

The financing program launched in 2023 attracted over **80 project proposals**, with total capacities exceeding **1,000 MWh**, demonstrating a very high interest from private investors.

Notable beneficiaries of the PNRR funding include:

- **Simtel Team / Energy Capital Group** – construction of a **98.6 MW / 196 MWh** storage facility at *Iaz, Caraș-Severin County*, with eligible costs exceeding **RON 50 million**;
- **Renovatio Trading** – a project of **30 MW / 60.96 MWh** in *Toplița, Harghita County*, eligible for **RON 111.5 million** in grants;
- **Electrica S.A.** – a **35 MW / 70 MWh** storage project at *Fântânele, Mureș County*, including a 110 kV transformer substation.

The **Ministry of Energy** continues to support such initiatives, emphasizing that storage capacities are indispensable for the **integration of variable renewable generation** and for **enhancing grid flexibility**.

#### 3.2 European and Private Initiatives

Romania is also participating in several European initiatives aimed at developing large-scale energy storage technologies. Through partnerships with entities such as the **European Investment Bank (EIB)** and the **World Bank**, feasibility studies have been launched for the potential construction of **pumped-storage hydro-power plants (PSH)** and **hybrid energy systems** combining renewable generation with battery storage.

In addition to public programs, **private sector involvement** has intensified significantly. Major domestic and international companies — including **Monsson, Prime Batteries Technology, Nova Power & Gas, Renovatio, Electrica, and Hidroelectrica** — are actively developing projects that will collectively increase the country's storage capacity to more than **1 GWh** by 2026.

#### 4. Challenges in the Development of Energy Storage in Romania

Despite recent progress, Romania still faces a number of technical, economic, and regulatory obstacles that limit the large-scale adoption of storage systems.

##### 4.1 Technical and Infrastructure Challenges

The main technical limitations concern:

- **Grid integration** – the lack of sufficient flexible substations and transmission lines for connecting large-scale battery systems;
- **Aging infrastructure** – much of the national grid requires modernization to accommodate bi-directional electricity flows;
- **Limited local production capacity** for batteries and related components, leading to dependence on imports and longer implementation times.

Furthermore, **hydrological variability** poses challenges for pumped-storage systems, as reduced water inflows in drought years may affect their efficiency.

##### 4.2 Economic and Financial Constraints

Although the costs of lithium-ion batteries have decreased globally, they still represent a **significant investment burden** for developers. According to estimates from 2025, the **levelized cost of storage (LCOS)**

for large-scale batteries in Romania ranges between **€120–150/MWh**, depending on the technology used.

Additionally, **the absence of a mature market for ancillary services and capacity remuneration** makes it difficult for investors to recover costs solely through energy arbitrage. This situation highlights the need for new **regulatory mechanisms** that adequately reward storage services such as **frequency regulation, peak-load management, and balancing support**.

#### 4.3 Legislative and Regulatory Barriers

The **legal framework** for energy storage in Romania is still evolving. Although ANRE has introduced a dedicated **“License for energy storage operation”**, many associated regulations — including taxation, grid connection, and market participation rules — remain ambiguous. Another challenge concerns **the classification of storage facilities** as both producers and consumers, which complicates tariff calculations and financial reporting.

In addition, the **long permitting and environmental approval procedures** can delay project development by more than 12–18 months, particularly for pumped-storage hydropower plants.

#### 5. Perspectives and Future Directions

The medium- and long-term prospects for energy storage development in Romania are strongly positive. National and European projections indicate that **installed storage capacity will exceed 2–4 GW by 2030**, and could surpass **10 GW by 2050**, if current projects and policy measures are implemented as planned.

In the near term, the following directions are considered essential:

- **Accelerating the deployment of battery energy storage systems (BESS)** to accompany renewable generation projects;
- **Modernizing the transmission and distribution grid** to allow greater operational flexibility;
- **Implementing new remuneration schemes** for storage-related services in the balancing market;
- **Encouraging local production and R&D** in advanced battery technologies;
- **Resuming feasibility studies** and launching investments in large pumped-storage hydropower plants such as *Tarnița-Lăpuștești*.

In parallel, Romania must strengthen **regional interconnections** with neighboring countries to improve grid stability and facilitate energy exchanges in periods of surplus or deficit.

#### 6. Conclusions

Electrical energy storage represents a **strategic pillar** of Romania's energy transition and a **key requirement** for the stability and resilience of the national power system. Although current installed capacities are still modest —

roughly **400 MW / 1 GWh** by the end of 2025 — the pace of development is accelerating rapidly.

The combined use of **battery energy storage systems** and **pumped-storage hydropower** offers Romania a viable pathway to balance renewable generation variability, reduce dependence on electricity imports, and increase energy security.

To achieve the 2030 objectives, it is essential to maintain a consistent public-private partnership framework, ensure predictable financing mechanisms, and streamline the legislative process for energy storage projects.

In conclusion, **the expansion of storage capacities is not merely a technical option but a strategic necessity** for Romania's sustainable energy future.

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### Abstract

The results of the study of the wear characteristics of detonation composite nanocoatings based on magnesium orthosilicate under conditions of high-temperature friction under constant load in the field of sliding speeds, on the surface of which stable antifriction structures are formed under conditions of elevated temperatures, are presented. The structural-phase composition of the coatings was determined by methods of modern physical analysis and the complex of high-temperature compounds of the surface layers was determined. The developed and studied coatings have high and stable antifriction properties. It was determined that the antifriction property under friction loading is due to the self-ordering of surface high-temperature oxide and oxygen-free structures, which are characterized by low shear resistance and work as solid lubricants that modify the contact surfaces and prevent damage to moving joints.

**Keywords:** composite coatings, wear intensity, structural-phase composition, oxide structures, solid lubricants.

Wear of friction pairs reduces the resource, at the same time, the use of lubricants in friction units increases the duration of their operation. At the same time, whatever modern materials are used as friction pairs, the most effective and reliable minimization of wear parameters is due to the use of lubricating and technical components in the form of liquid oils or solid lubricants. At the same time, the prerequisites for ensuring wear resistance in extreme operating conditions, which include both high loads and speeds of movement, and increased operating temperatures, remain relevant.

As a rule, the use of polymer lubricants is effective from room temperature to 300°C, solid laminar lubricants extend the operating range to 400°C; graphite, being a layered solid material, is an exception, as it provides lubricating ability at temperatures exceeding 450°C. At the same time, stable fluorides and metal oxides can be used as lubricants at temperatures above 1000°C [1-4].

One of the directions of increasing thermal resistance is connected with the search for regularities of structure formation of a complex of high-temperature surface oxide and oxygen-free magnesium compounds, which have high thermo mechanical properties and have low shear strength under friction. These studies are based on tribotechnical tests of composite coatings containing magnesium compounds, in particular, orthosilicate. Development and application of powder compositions containing magnesium orthosilicate as a basis for detonation-gas spraying of antifriction coatings operating in extreme conditions is one of the priority directions of modern tribotechnical materials science and an urgent task of increasing operational reliability and extending the production life of parts.

**The purpose of the presented work** is to study the wear sequence under high-temperature friction conditions of coatings based on magnesium compounds, to study their structural and phase composition, and to analyze the structure formation of heat-resistant surface

oxide and oxygen-free components with low shear resistance, which play the role of a solid lubricant during friction.

**Materials and research methods.** As a powder base for spraying high-temperature coatings, a heat-resistant oxide compound was used, namely, magnesium orthosilicate with the chemical formula  $2\text{MgO} \cdot \text{SiO}_2$ , which has significant mechanical and thermal properties and is widely used as a refractory. For the purpose of heterogenization, nanosized impurities of chromium, zirconium, nickel, titanium, aluminum, silicon and carbon were added to the initial powder base material. Further step-by-step development involved the use of mechanochemical synthesis (MCS) technology, as a result of which a multicomponent mixture was obtained, individual granulometric particles of which, as a result of selective interaction, which is due to thermodynamic and diffusion characteristics, consisted of micro volumes of several nanocomponents. Thus, a mixture of micron-sized base particles and nanosized doped phases was obtained. Subsequently, the mechanical mixture was mixed until complete and uniform distribution of structural components and a state of suitability for spraying was achieved.

The nanosized powder conglomerate obtained in this way was sprayed by the detonation-gas method onto ring samples of the HN78T alloy. The physical and mechanical properties and patterns of friction and wear of the coatings at elevated temperatures were tested according to the end-face scheme on universal friction machine M-22PV at a sliding speed of 1.5 m/s and a load of 7.5 MPa. The temperature was measured with a thermoelectric thermometer of the KTHA type at a distance of 1-2 mm from the friction surface according to the standard method [9]. The adhesion strength was determined by the pin method, which for coatings based on orthosilicate was over 89 MPa with a residual porosity of 0.5-1.0%, along with this, after preliminary finishing grinding their roughness parameter was equal to  $R_a$  0.32-0.63. At the same time, the research program provided for a comparative analysis



of the friction parameters of the developed coatings with the values of control coatings based on both tungsten carbide type WK-15 and alloyed nichrome.

The wear intensity, friction coefficient, and condition of working surfaces were determined as criteria for the performance of coatings [10].

When studying the patterns of wear and structural transformations under friction conditions and establishing the technology-structure and structure-property relationships, a complex of modern physicochemical methods of structural-phase analysis was applied, capable of studying surface layers at the macro- and microscopic levels. The comprehensive research methodology included metallography (optical microscope "Neophot-32" with an attachment); durometric analysis (hardness tester M-40 from LECO); scanning electron microscopy (scanning electron microscope JSM-840); X-ray structural phase analyzer (diffractometer DRON-UM1).

**Research results and their discussion.** The contact interaction of surfaces under friction conditions is a complex sequence of cooperative influence of both external and internal factors, on which the regularities that determine the course of friction and wear processes depend; they determine the degree and gradients of elastic-plastic deformation, temperature, activation

level and a number of associated phenomena and ultimately determine the leading type of wear.

The results of high-temperature friction wear tests of magnesium orthosilicate-based coatings and control coatings are presented in fig. 1. The studies were conducted in a field of monotonically increasing temperatures at a constant load corresponding to 7.5 MPa.

The obtained results allow us to clearly distinguish, under the given experimental conditions, the satisfactory antifriction properties of coatings based on magnesium orthosilicate, which are due to the long-term and minimum values of both the wear intensity and the friction coefficients. According to the authors, under the given test conditions, the value of the friction coefficients is determined not so much by the function of the normal load, but by the dependence on the tribo-physical processes that are formed as a result of the additive action of the load, sliding speed, temperature and the generalized vector of friction parameters (material, environment, conditions, etc.). At the same time, the nature of the values of the friction coefficients on the sliding speed under the test conditions is consistent with the profile of the dependence of the wear intensity, and its stability indicates the high workability of the studied coatings based on orthosilicate.

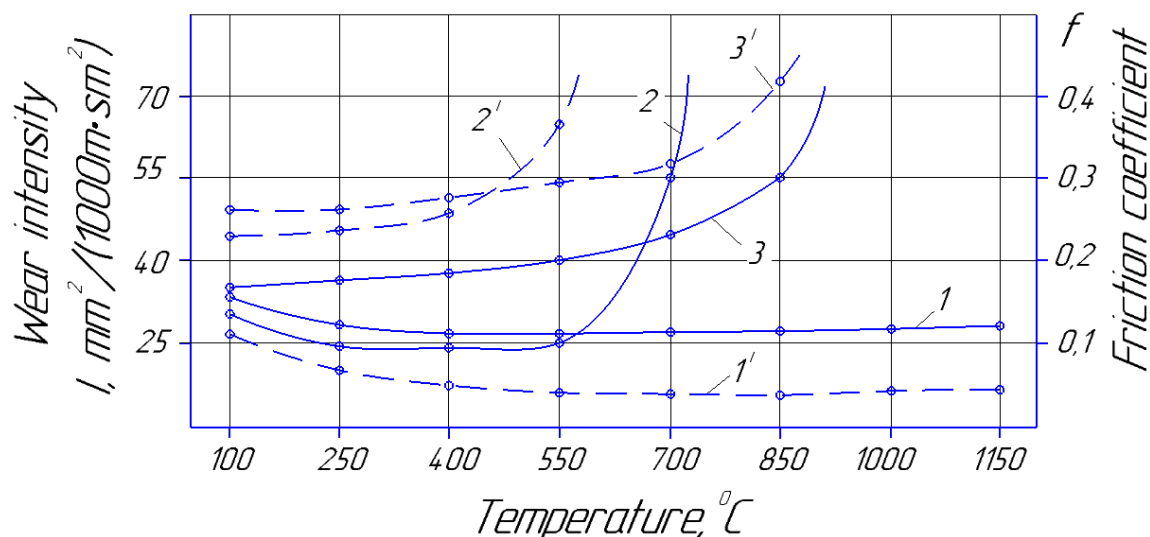


Figure 1 – Dependence of wear intensity (1, 2, 3) and friction coefficients (1', 2', 3') on the temperature of coatings based on magnesium orthosilicate (1, 1'), WK-15 (2, 2'), alloyed nichrome (3, 3') at  $P=7.5$  MPa.

The topography of the working surface of silicate-based coatings in combination with physical and mechanical characteristics determines their operational properties, including wear resistance. Studies have shown that during the running-in process, the original technological relief is removed, the chemical composition, structure of the surface layer and its geometry are radically changed, which affects wear resistance. At the same time, a new surface quality is formed, which contributes to the formation of balanced roughness, which causes minimal and stable wear.

Thus, the initial technological roughness is converted into optimal operational roughness, which causes favorable wear. At the same time, the sprayed layer is characterized by a heterogeneous dispersed

structure with a quasi-ordered lamellar appearance and fits tightly to the base, copying the relief, while the accumulation of films, slag inclusions and other contaminants, as well as defects in the form of micro pores and micro cracks, are not detected. Profiling of the contact zone (fig. 2.) indicates the absence of damage to the surface layers and leveling of the working surface, which mainly occurs due to the removal of protrusions, and contributes to the formation of continuous oxide high-temperature structures, which is also consistent with electron micrographs of friction surfaces.

When determining the structure, we relied on the results of micro X-ray structural analysis (MRSA) performed on the Camebax SX installation, which allowed us to classify the structure of the studied coatings as a

multicomponent fine-grained aggregate, the basis of which consists of homogeneous hexagonal magnesium orthosilicate and an almost uniformly defined significant amount of finely dispersed inclusions of carbides, especially silicon carbide (SiC) and a fine aggregate of high-temperature strengthening compounds, which are silicides  $\text{Cr}_2\text{Si}_3$ ,  $\text{CrSi}_2$ ,  $\text{Zr}_3\text{Si}_2$ ,  $\text{TiSi}$ ,  $\text{TiSi}_2$  and aluminides  $\text{TiAl}_3$ ,  $\text{TiAl}$ ,  $\text{ZrAl}_3$ ,  $\text{CrAl}_4$ , as well as significant colonies of metal carbides that are part of the coating. In addition, significant intermetallic formations in the form of spherical nanoparticles of the  $\text{ZrCr}_2$ ,  $\text{ZrV}_2$ ,  $\text{NiTi}$ ,  $\text{NiAl}$  types were identified, which stabilize the structure, and non-oxide fragments of ternary compounds in the form of  $\text{MgSiC}$ ,  $\text{Cr}_2\text{SiC}$ ,  $\text{Ti}_3\text{SiC}_2$ ,  $\text{TiZrC}$ ,  $\text{ZrSiC}$ , which are characterized by significant hardness and strength under high-temperature friction conditions. Qualitative determination of phases through the

micro hardness of individual areas was also applied. Thus, micro areas with a micro hardness of 5.1-6.7 GPa are probably titanium carbosilicides, and zones with a micro hardness of almost 12.0 GPa are titanium carbides, values of 8.0 GPa most likely correspond to titanium silicides, while 9.3-10.2 GPa is a micro hardness that is close to the values of magnesium oxides. Thus, the structural-phase formations of coatings based on magnesium orthosilicate consist of chemical compounds, solid solutions and mechanical mixtures and are characterized by increased thermodynamic properties, namely hardness, strength and corrosion resistance, and provide considerable wear resistance and low friction coefficients under high-temperature friction conditions.

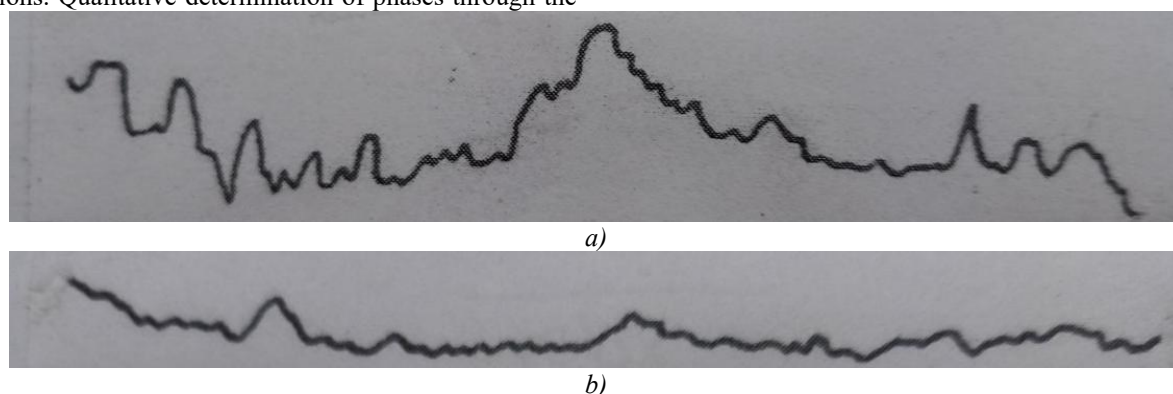


Figure 2 – Profilograms of friction surfaces of orthosilicate-based samples tested at: a – 50°C, b – 550°C ( $P=7.5$  MPa,  $WU\times1000$ ,  $GU\times40$ ).

Thus, the specified structural components of orthosilicate-based coatings, due to quantitative formations, provide high-quality components of solid solutions, chemical compounds and mechanical mixtures, which have increased temperature stability, satisfactory hardness, strength and corrosion resistance at elevated temperatures.

The problem of coating quality is inextricably linked with the optimization of the technological process. To obtain improved coatings, technological parameters were investigated, primarily the particle size distribution, loading depth, barrel filling degree, working gas ratio and spraying distance [11]. In addition, by controlling the technological process of increasing the efficiency of the studied coatings, not only the required chemical composition was implemented, but also the predicted structure was obtained, which is determined by a set of properties that determine the stability of structural adaptability. At the same time, the possibility of obtaining constant quality was achieved, namely, the variation of strength and plastic characteristics in the samples of one batch that were sprayed was stably about 5-10%.

The study of the physical mechanisms of the formation and evolution of structural-phase states of secondary structures under conditions of mechanochemical activation at high-temperature friction is one of the important tasks of controlling the antifriction properties of coatings based on magnesium orthosilicate when regulating their tribotechnical properties. For comprehensive and reliable information in the study of thin

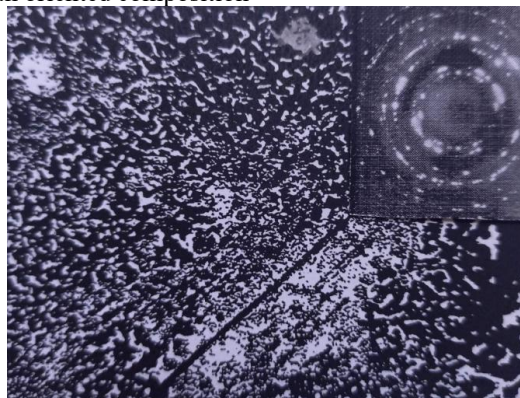
surface layers in which the processes of structural-thermal activation occur, the X-ray photoelectron spectroscopy (XPS) method was additionally applied, with the help of which the microstructure was analyzed and the nature of the phases, their crystal structure and the parameters of the elementary cells, which are necessary for identifying the composition within the regions of their homogeneity, were determined. The obtained results allowed us to generalize that the initiation of physicochemical transformations due to elastic-plastic deformation is primarily manifested in the process of inversion of interaction with air oxygen and, as a result, the reformation of secondary films by additional formation of oxide compounds within the structural components of the orthosilicate composition, which, according to its stoichiometric composition, as a result of solid-phase tribochemical and diffusion processes, forms a powerful complex of stable thermodynamic compounds of the second type in the form of  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Cr}_2\text{O}_3$ ,  $\text{MgO}$ , which additionally synthesize both solid solutions of the type  $2\text{Cr}_2\text{O}_3\text{-SiO}_2$ ,  $\text{MgO-Al}_2\text{O}_3$ , and complex oxides in the form of aluminosilicates  $\text{Al}_2\text{SiO}_5$ ,  $\text{Al}_2\text{SiO}_4$ ,  $\text{AlSi}_3\text{O}_8$ , which constitute compounds with high thermal stability, as well as spinel phases with significant thermal stability, such as  $\text{Mg}_2\text{TiO}_4$ ,  $\text{MgAl}_2\text{O}_4$ ,  $\text{MgTi}_2\text{O}_5$ ,  $\text{MgZrO}_3$ ,  $\text{MgCr}_2\text{O}_4$ , in addition, the presence of binary compounds of the type  $\text{TiO-ZrO}_2$ ,  $\text{MgO-TiO}_2$ ,  $\text{MgO-ZrO}_2$  has been identified, while the possibility of the presence of ternary compounds, such as  $\text{Mg-ZrO}_2\text{-TiO}_2$ ,  $\text{MgO-Al}_2\text{O}_3\text{-TiO}_2$ ,



is not excluded. It is worth noting that at elevated temperatures, protective oxide structures that form a film on friction surfaces, in which shear deformation is localized during friction, determining the quality of friction, are in dynamic equilibrium and have the property of self-lubricating. However, due to statistical regularities, the processes of regulation of secondary self-lubricating structures on different parts of the working surface as a result of contact discreteness do not coincide in stages. The authors believe that the process of their formation does not occur simultaneously on the entire contact surface, but only on local fragments of the actual area, while their additive distribution is a stable structural-temporal state.

For a deeper understanding, the surface structure in which the activation processes occur was investigated using transmission electron microscopy. Fig. 3 shows a typical topography of the surface of an orthosilicate-based coating and an electron diffraction pattern obtained from a section with an area of about  $0.5 \mu\text{m}^2$ , which consists of a large number of reflections, indicating a polycrystalline state and representing an oriented mixture of highly dispersed phases. The surface structure of this coating is an oriented composition

of highly dispersed crystalline phases. The decrease in grain size is accompanied by an increase in their strength and hardness. In this case, the micro hardness of the surface layer is 19.0–21.0 GPa (with an initial one of about 16.0 GPa). Thus, low and stable values of both friction coefficients and wear rates of coatings at elevated temperatures are ensured by the formation of a coherent dynamically stable conglomerate of heat-resistant oxide structures, which are characterized by a small shear resistance. It should be noted that the structure itself can change within certain limits, but the general order, i.e. the dynamics of their formation and destruction, is constant. At the same time, it provides screening of adhesive-molecular interaction during friction and under conditions of local contact pressures and temperatures forms dense heterogeneous heat-resistant and fairly plastic surface films without cracks and chips, which by their properties have high adhesive activity to the surface and are a barrier to oxygen diffusion and contribute not only to reducing the oxidation rate and increasing heat resistance, but also play the role of solid lubricants.



*Figure 3 - Friction surface and electron diffraction pattern orthosilicate-based coating ( $750^\circ\text{C}$ ,  $V=1.5 \text{ m/s}$ ,  $P=7.5 \text{ MPa}$ .)*

Thus, the means of regulating wear and ensuring self-lubrication of magnesium silicate-based coatings under conditions of high-temperature friction is the action of heat-resistant surface oxide structures, which, during cooperative self-organization, provide an additive complex of properties of surface structures that have the ability to self-lubricate and prevent direct contact of surfaces, while effectively reducing the friction force, wear intensity, and preventing unacceptable destruction processes.

From the point of view of structural-thermodynamic mapping, the systemic ordering of surface oxide films under high-temperature conditions can be physically realized only through a structure that adapts through evolution and which can be considered during friction as adequate elementary physicochemical processes and mechanisms of self-ordering that cause self-lubrication under high-temperature friction conditions.

Fig. 1 (curves 2, 2<sup>1</sup>) also presents the results of tests of coatings of the type WK15, sprayed with tungsten carbide powder, which were used as reference coatings in the study of the patterns of friction and wear of coatings with orthosilicate. Coatings of the type WK-15, as a classic wear-resistant material, are widely

implemented to protect against wear a significant range of parts of different design and purpose. As it was established, at sliding speeds of more than 1.7 m/s, the tendency to increase their wear is determined by the temperature factor, which ultimately turns out to be decisive in the development of destructive processes.

For coatings based on nichrome, alloyed with aluminum and boron, (fig. 1, curves 3 and 3<sup>1</sup>) is characterized by a slow increase in wear intensity with increasing temperature factor. The study of the phase composition revealed the presence in the composition of both a solid solution based on nickel, and, mainly, dispersed compounds of nickel aluminides ( $\text{NiAl}$ ,  $\text{Ni}_3\text{Al}$ ), chromium borides ( $\text{Cr}_2\text{B}$ ,  $\text{Cr}_3\text{B}_3$ ). The passive capabilities of secondary structures with increasing test temperature are suppressed by the development of plastic deformation, as a result, the dynamic equilibrium shifts towards increasing activation energy, and the type of wear changes qualitatively. The specifications of metallographic analysis of their friction surfaces at speeds of 1.8 m/s are random local tearing, scratches, and characteristic of the initial development of setting processes.

Thus, the detonation coatings based on magnesium orthosilicate, developed by the authors, are characterized by high antifriction properties and significantly exceed the control coatings in terms of operational capabilities, in addition, they are characterized by significant adhesion strength and the ability to vary secondary structures due to the composition, which cause self-lubrication. The conducted studies indicate the feasibility of using self-lubricating antifriction coatings to increase the operational reliability and durability of parts operating under high-temperature friction conditions. It can already be noted that their practical implementation will ensure reliability, increase the resource and, in case of operational damage to parts, reduce repair costs during their restoration. In technical systems, there are nodes that are subject to wear during the friction process and, as a rule, cause operational malfunctions over time. Such units include, for example, crankshafts, seats, disk and oval surfaces of products, housing parts, moving pairs, hinges of guide surfaces, cams, sliding supports, pairs with reciprocating movement, guide slides, lever parts, high-speed and heavily loaded joints, in which the use of traditional lubricants is undesirable. From our considerations, coatings developed on the basis of heat-resistant magnesium oxides can be considered as an alternative to other promising materials for operation in high-temperature units of modern technology, including aerospace.

It should be noted that the created composite powder based on magnesium orthosilicate for the formation of self-lubricating antifriction coatings operated under high-temperature friction conditions can be used by any technological methods using powder materials.

### Conclusions

1. Magnesium orthosilicate-based coatings developed and tested under high temperature conditions are characterized by stable and low friction coefficients and wear rates. In high-temperature testing mode at a load of 7.5 MPa and a sliding speed of 1.5 m/s, they have friction parameters significantly lower than those of control coatings by 3.5-8.0 times.

2. Based on mechanochemical technology, composite powder mixtures based on magnesium orthosilicate were obtained, consisting of a nanocomposite conglomerate of micron-level base particles and nanoalloyed phases, and cause-and-effect relationships between technological and operational factors of the formation of self-lubricating coatings were established.

3. The optimal mode of detonation-gas spraying of orthosilicate compositions has been worked out, which reproduces not only the planned chemical composition, but also provides a predicted structure, which modernizes the friction surface and ensures guaranteed quality of coatings. At the same time, it is emphasized that during spraying, the variation of strength and plastic properties in samples of one batch is stable and is 5-10%.

4. The structural and phase composition of coatings based on magnesium orthosilicate has been established as a multicomponent fine-grained aggregate of hexagonal orthosilicate with an almost uniform distribution of finely dispersed high-temperature inclusions

of carbides (TiC, ZrC, SiC), silicides (TiSi, CrSi<sub>2</sub>, Zr<sub>3</sub>Si<sub>2</sub>), aluminides (TiAl, ZrAl<sub>3</sub>, CrAl<sub>4</sub>), in addition, intermetallic formations (NiAl, NiTi, ZrCr<sub>2</sub>) have been identified, and ternary compounds in the form of MgSiC, TiZrC, ZrSiC have also been discovered, which are generally characterized by increased thermodynamic properties, high hardness and strength, and corrosion resistance.

5. It is noted that the tendency of coatings to passivation is due to diffusion and tribochemical processes, which cause the formation of a quasi-spherical oxide protective film, in which shear deformation is localized during friction. At the same time, it provides shielding of adhesive-molecular interaction, has high adhesive activity to the surface and under conditions of high-temperature friction increases heat resistance and performs the role of solid lubricants, while reducing the friction force, wear intensity and preventing unacceptable destruction processes.

6. The developed self-lubricating composite coatings based on magnesium oxide compounds extend the achievements of modern tribotechnical materials science. The studied self-lubricating compositions based on magnesium orthosilicate can be used both for strengthening and for high-quality restoration of worn parts by any technological methods using powder materials.

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## RESEARCH ON THE BRAKING PROCESS OF THE LIFTING MECHANISM OF LOAD-LIFTING MACHINES

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### Abstract

Ensuring the safety, reliability and durability of lifting machines is a critical task in mechanical engineering and operation. Lifting mechanisms, as key components of these machines, operate under conditions of significant cyclic loads and high requirements for load positioning accuracy. The braking process is a decisive stage in the working cycle, as both the safety of personnel and equipment and the dynamic loads on structural elements depend on its effectiveness. Suboptimal braking modes can lead to dynamic overloads, premature wear of brake components, hydraulic drives (in the case of hydraulic brake systems) and, as a result, to emergency situations.

**Keywords:** hoisting mechanism; lifting machine; braking; dynamics.

Modern lifting mechanisms often use multi-stage, combined or intelligent braking systems (e.g., a combination of electric, hydraulic and mechanical braking). Despite significant progress in the design of braking devices, a comprehensive analysis of the dynamic processes that occur during transient braking modes remains insufficiently studied, especially for machines with high lifting capacity and operating speed. Existing calculation methods are often based on simplified models that do not fully take into account the influence of the stiffness of elements, the elastic properties of ropes, and the nonlinear dynamics of brake drives.

The aim of this study is to develop and verify a refined mathematical model of the lifting mechanism braking process, as well as to experimentally investigate the influence of key operating parameters (speed, load mass, brake activation moment) on the dynamic characteristics of the system in order to optimise operating modes and improve the overall reliability of the mechanism.

The scientific novelty of the work lies in the creation of a model that allows predicting the dynamic overload coefficient in the lifting mechanism for different braking strategies, integrating the nonlinear characteristics of the braking device and the elastic-inertial properties of moving masses.

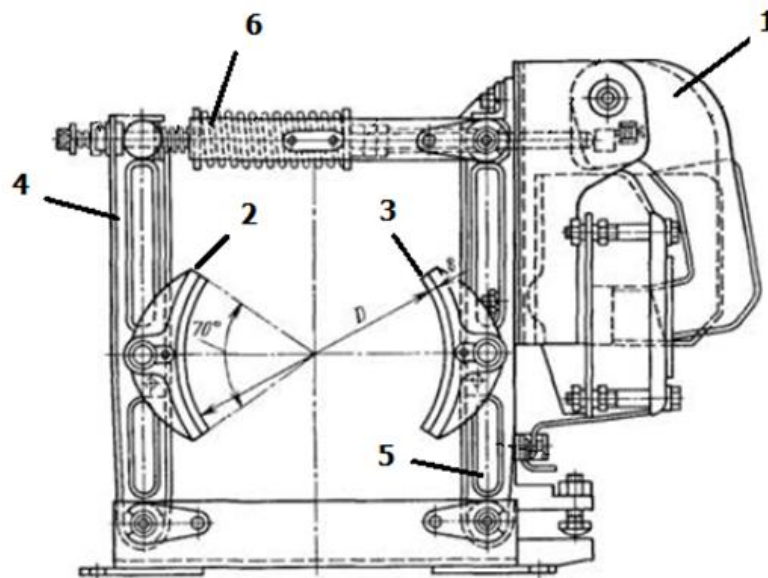
The practical significance of the results lies in the possibility of using the obtained data for:

- Justifying the selection and adjustment of braking systems during design.
- Developing adaptive braking control systems based on predictive models.
- Establishing reasonable maintenance standards that prevent catastrophic wear.

A large number of different designs of double-shoe brakes are used in lifting and transport mechanisms. These consist of levers and two shoes, diametrically opposed to the brake pulley, which are released by a lever system. Braking occurs as a result of the creation of friction between the brake pulley, connected to one of the mechanism's shafts, and the brake shoes, fixed to the brake racks and further to the base installed on the metal structure of the trolley or crane.

Special brake elements are used as the release device: electromagnets, electrohydraulic and electromechanical pushers.

For shoe brakes, mainly MP and MO-B type electromagnets are used, which are characterised by a short stroke. They are designed to be installed directly on the brake stand, for example, TKT brakes (Fig. 1).



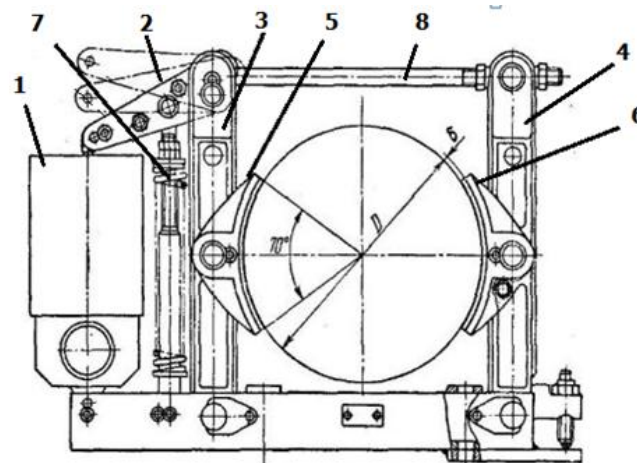
1-electromagnet armature; 2,3 – brake shoes; 4,5 – levers; 6 – spring system; 7 - coil  
Fig. 1. Shoe brakes driven by an electromagnet

The disadvantages of electromagnetic brakes include relatively low durability and the inability to regulate the speed of the armature.

Given the above disadvantages of electromagnets, electrohydraulic and electromechanical pushers are increasingly being used. An electrohydraulic pusher is an independent mechanism consisting of a centrifugal pump driven by a low-power electric motor and a piston group connected to the brake lever system. In this device, electrical energy is converted into mechanical energy in the form of linear motion of the moving pusher rod.

The advantage of electro-hydraulic pushers over electromagnetic ones is the smooth operation of the device and the possibility of high switching frequency. It should also be noted that they are easy to operate and significantly reduce starting currents.

Electro-hydraulic pushers also have some disadvantages. For example, the presence of working fluid in the housing requires sealing. Pushers manufactured by industry can only operate in a vertical position. The design of the brake driven by an electrohydraulic pusher includes a locking spring, as shown in Figure 2.2.

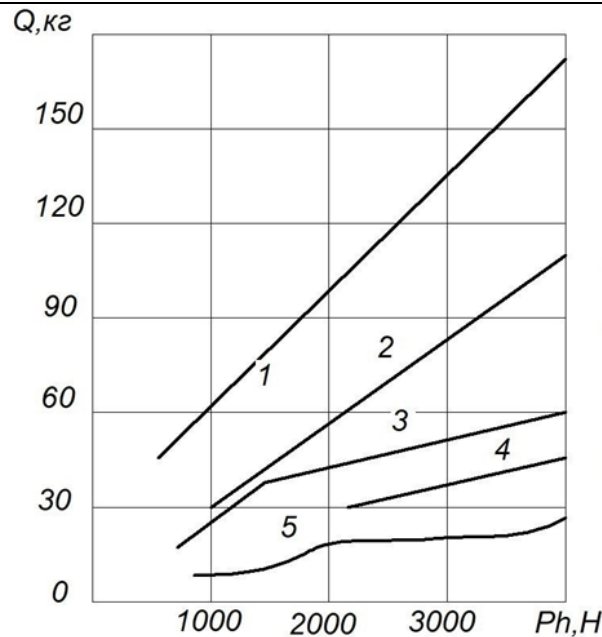


1 – electrohydraulic pusher; 2,3,4 – levers; 5,6 – shoe brakes; 7 – spring mechanism; 8 – rod  
Fig. 2. Shoe brakes with electrohydraulic drive.

Brake actuators use DC and AC brake solenoids, as well as magnetic-hydraulic, electro-hydraulic, electromechanical, screw and centrifugal pushers.

A comparison of the dead weights of different types of brake actuators (Fig. 3.1) shows that electromagnets have low material consumption. In addition to

this disadvantage, braking electromagnets do not operate at high switching frequencies, have high switching power, the braking process is beacon-like, they are very sensitive to misalignment, and have insufficient durability.



1 – Electromagnetic; 2 – Magnetic-hydraulic pushers (MHP); 3 – Electromechanical centrifugal (ECP); 4 – Electromechanical screw pushers (ESP); 5 – Electrohydraulic pushers (EHS)

Fig. 3. Dependence of the dead weight  $Q$  of shoe brake actuators on the work  $Ph$  performed by the actuator

Due to these shortcomings, electromagnets have been replaced by other types of drives.

The time required to raise and lower the rod in an EMSH is significantly longer than in an EGS, and an additional forcing device is required to accelerate the lowering of the rod.

EMSHs are characterised by more rigid operation compared to EGSs. Their manufacture does not allow EMSHs to be recognised as an equivalent replacement for EGSs.

Magneto-hydraulic pushers (MHPs) combine the advantages of electromagnetic and hydraulic drives. MHPs are distinguished by a smooth activation process even under overload conditions, low time values and, consequently, fast brake release, the absence of rotating parts, low wear of moving parts, as well as simplicity and reliability.

However, MGS cannot compete with EGS because they are several times heavier than EGS, require 2-5 times more winding wire to manufacture, and consume 8-10 times more power than EGS.

Comparing ECS and EGS, it should be noted that EGS are characterised by the independence of the thrust force from the position of the rod, while for ECS with a rod mechanism, the thrust force varies depending on the position of this mechanism, and therefore the stroke of the rod and the magnitude of the thrust force are not fully utilised in ECS. A significant advantage of ECSH with active mass in the form of balls and cylinders over EGSSH is the ability to change the thrust force of the rod according to a predetermined law, since this force is determined by the shape of the surfaces on which the active masses roll. The maximum value of the thrust force in EGSSH is significantly higher than in ECSH.

The maximum stroke in an ECF is limited to 50-60 mm, while in an EGF it is practically unlimited. The

average piston speed in an EGF without the use of control devices increases the average speed of the ECF pressure rod by 4-6 times.

The use of control devices allows changing the speed in the ECU during the absolute stroke, and in the EGU during both the reverse and working strokes; at the same time, the control range in the EGU allows for more than a 25-fold change in speed, which is much more than in the ECU.

The EGSH also has the advantage that during the reverse stroke of the piston, the axles are transformed from a source of mechanical energy into a damper-retarder with an adjustable speed of the executive body, while the set speed of movement throughout the entire reverse stroke remains practically constant. As for ECS, if it is necessary to reduce the reverse stroke time, they require the use of special electric motors with a built-in brake.

The labour intensity of manufacturing ECS is 30-50% higher than that of EGS, which is due to their greater design complexity. The consumption of active and structural materials, as well as electricity, in ECB is 1.2-1.3 times higher.

After analysing a comparative assessment of these device options, it can be concluded that the most promising drive for shoe brakes is electrohydraulic pushers (EGP).

Brakes used in PTMs are characterised by repeated short-term operation, in which braking is periodically interrupted by pauses. The volume temperature of the brake friction unit, established in the mode of repeated short-term braking, is determined by the formula from:

$$v = v_0 + W_{T.n.} \left( \frac{1}{\sigma^1 \cdot A_{вен} \cdot t_{охл}} + \frac{1}{2G \cdot c} \right), \quad (1)$$

where  $v_0$  – initial volumetric temperature of the friction node;

$W_{T.n.}$  – braking work that has turned into heat;



$\sigma^1$  – external heat transfer coefficient;  
 $A_{\text{BEH}}$  – area of the open ventilated surface of the friction unit;  
 $t_{\text{oxл}}$  – cooling time (pause);  
 $G, c$  – weight and specific effective heat capacity of the friction unit.

The braking process, which has turned into heat, is characterised by the design features and operating parameters of the mechanism and is determined by the dependence:

$$W_{\text{т.п.}} = \frac{M_{\text{т}} \cdot \pi \cdot n_{\text{т}}}{30} \cdot \tau_{\text{т}}, \quad (2)$$

where  $M_{\text{т}}$  – braking torque;

$n_{\text{т}}$  – number of revolutions per minute of the drive motor of the mechanism (brake pulley before braking begins);

$\tau_{\text{т}}$  – braking time.

Under equal friction conditions, the brake in the repeated short-term braking mode is determined by the speed at which the friction pair elements begin to contact, the braking time, and the duration of the pause between braking.

In modern military-industrial complexes, shoe brakes driven by an electro-hydraulic pusher are widely used. These brakes are characterised by a significant response time  $\tau_{\text{т}}$ , i.e. the time from the moment the drive motor of the mechanism is switched off to the moment of contact between the friction pair elements of the brake, according to the formula:

$$\tau_{\text{cp}} = \tau_{\text{ch}} + \tau_{\text{внб}} + \tau_{\text{AB}}, \quad (3)$$

where  $\tau_{\text{ch}}$  – voltage drop time, which is a constant value for this type of electrohydraulic pusher;

$\tau_{\text{внб}}$  – the time during which the centrifugal pump wheel, rotating by inertia, and the pusher motor rotor

are able to maintain pressure under the piston, preventing the externally loaded rod from lowering;

$\tau_{\text{AB}}$  – The downward movement time of the rod depends on the stroke length, the viscosity of the working fluid, and the hydraulic characteristics of the flow part of the electric hydraulic pusher (EGSH) pump.

The passport values of the brake response time with EGS depend on the type and size within the range of 0.2 to 0.8 s, which is 10-20% of the braking time  $\tau_{\text{т}}$  for movement and turning mechanisms and up to 50-100% for load lifting mechanisms. For this reason, two periods should be distinguished in the braking process of the mechanism (Fig. 4). In the first period (during  $\tau_{\text{cp}}$ ), the rotational speed of the brake pulley changes under the action of the resistance moment in the absence of both the moment  $\mu_{\text{д}}$  from the drive motor of the mechanism and the braking moment  $\mu_{\text{т}}$ , which is moving; at the same time, in the load lifting mechanism, the rotational speed of the brake pulley decreases when braking the load (Fig. 4.1, a) that is being lifted, and increases when braking the load (Fig. 4.1, b) that is being lowered, while in the movement and rotation mechanisms it only decreases (Fig. 4.1, c). In the second period (during  $\tau_{\text{т}}$ ), the friction pair elements of the brake come into contact with each other, with an intense decrease in speed under the action of the braking torque  $M_{\text{т}}$ .

In real operating conditions of shoe brakes of cranes with EGSh, the contact of the elements of the brake friction unit begins not at the nominal speed  $n_0$  of the working movement, but at a speed  $n_{\text{т}}$  different from the nominal one.

Let us quantitatively estimate the change in the rotational speed of the brake pulley of the load lifting mechanism during the time  $\tau_{\text{cp}}$  of brake operation.

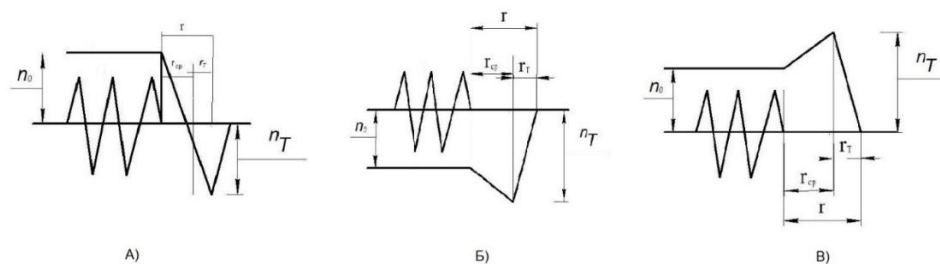


Fig. 4. Change in the rotational speed of the brake pulley.

As a result of mathematical calculations, the following expression was obtained, taken from the example of , for the speed at which the elements of the friction brake assembly of the load lifting mechanism begin to make contact.

$$n_{\text{т}} = n_0 \pm \frac{187,5 \cdot S_6 \cdot D_6 \cdot k \cdot \tau_{\text{cp}}}{\Sigma m D_{\text{np}}^2 \cdot \eta_6 \cdot i_0}, \quad (4)$$

where  $S_6$  – the force exerted by the rope attached to the drum of the lifting mechanism;

$D_6$  – diameter of the lifting mechanism drum;

$k$  – number of strands of rope fixed on the drum;

$\Sigma m D_{\text{np}}^2$  – total inertia moment of the mechanism, reduced to the brake shaft;

$\eta_6$  – ККД, which takes into account losses in the drum shaft supports, as well as losses caused by rope roughness;

$\eta_0, i_0$  – total transmission ratio of the mechanism and total efficiency of the mechanism.

The rope force  $S_6$  depends on the direction of rotation of the brake pulley:  
 when lifting a load

$$S_6 = \frac{Q}{R} \cdot \frac{1 - \eta_{6л}}{(1 - \eta_{6л}^m) \cdot \eta_{6л}^m}, \quad (5)$$

when lowering the load

$$S_6 = \frac{Q}{R} \cdot \frac{\eta_{6л}^{m-1} - \eta_{6л}^m}{1 - \eta_{6л}^m}, \quad (6)$$

where  $Q$  – cargo weight;  
 $\eta_{6л}$  – ККД each block of the pulley block;  
 $m$  – pulley ratio;

Total reduced torque  $\Sigma m D_{np}^2$  also depends on the direction of rotation of the brake pulley, braking when ascending or descending.

Having marked  $\frac{187,5 \cdot S_6 \cdot D_6 \cdot k \cdot \tau_{cp}}{\Sigma m D_{np}^2 \cdot \eta_6 \cdot \eta_0 \cdot i_0} = \Delta n_0$  can be recorded:

$$W_T = \frac{\pi \cdot M_T}{30} \cdot (n_0 \pm \Delta n_0) \cdot \tau_T^0, \quad (7)$$

$$\text{де } \tau_T^0 = \frac{\Sigma m D_{np}^2 \cdot (n_0 \pm \Delta n_0)}{375 \cdot (M_T \pm M_C)} \quad (8)$$

$M_C$  – moment of resistance, which can be expressed through the initial parameters of the mechanism

$$M_C = \frac{S_6 \cdot D_6 \cdot k}{2 \cdot \eta_6 \cdot \eta_0 \cdot i_0} \quad (9)$$

The expression for the volumetric temperature of the friction node of the brake of the load lifting mechanism in repeated short-term operation mode is written as:

$$v = v_0 + \left\{ \left[ n_0 \pm \frac{187,5 \cdot S_6 \cdot D_6 \cdot k \cdot \tau_{cp}}{\Sigma m D_{np}^2 \cdot \eta_6 \cdot \eta_0 \cdot i_0} \right] \cdot \left( \frac{1}{\sigma^1 \cdot A_{вен} \cdot t_{охл}} + \frac{1}{2G \cdot c} \right) \right\} \quad (10)$$

As an example, let us give a comparative calculation of the volume temperature of the friction node of the brake mechanism of a bridge electric crane with a lifting capacity of  $Q = 20$  т.

Initial data:

$Q = 20$  т; operating mode group – А4 (ПВ = 25%);  
 $n_0 = 720$  revolutions/wave;  $D_6 = 620$  mm;  $k = 2$ ;  
 $m = 4$ ;  $\Sigma m D_{np}^2 = 7,5$  kg · м<sup>2</sup> (when lifting); ;  $\Sigma m D_{np}^2 = 8,5$  kg · м<sup>2</sup> (when lowering cargo);  $\eta_6 = 0,98$ ;  $\eta_0 = 0,86$ ;  
 $i_0 = 31,5$ ; *brakes of the TKTG type* – 300M; for which  $\tau_{cp} = 0,35$  c;  $M_T = 60$  Н · м.

The calculation resulted in:

When lifting cargo –  $n_T = 265$  revolutions/wave;  $\tau_T = 0,063$  c;  $W_{T.л.} = 1040$  Н · м;

When lowering cargo –  $n_T = 1175$  revolutions/wave;  $\tau_T = 1,207$  c;

$$W_{T.п.} = 89140 \text{ Н · м};$$

Without taking into account the change in the rotational speed of the brake pulley, the following was obtained:

When lifting cargo –  $n_T = n_0 = 720$  revolutions/wave;  $\tau_T = 0,174$  c;

$$W_{T.л.} = 7870 \text{ Н · м};$$

When lowering cargo –  $n_T = n_0 = 720$  revolutions/wave;  $\tau_T = 0,74$  c;  $W_{T.п.} = 33410$  Н · м.

The comparison of the calculated values of the steady-state volume temperature of the brake friction unit, obtained with and without, can be characterised in our example by comparing the corresponding calculated values of the braking work converted into heat:

$$\frac{1040 + 89140}{7870 + 33410} = 2,18$$

The proposed method of thermal calculation significantly affects the determination of the friction temperature of brake components.

### Conclusions

1. A refined mathematical model has been developed: During the study, a refined mathematical model of the lifting mechanism braking process was developed and verified. Unlike simplified models, this model adequately integrates the nonlinear characteristics of the braking device and takes into account the elastic-inertial properties of the moving elements of the system (in particular, ropes and structural elements).

2. Critical dynamic dependencies have been established: Through numerical modelling and experimental testing, the direct and nonlinear influence of key operating parameters (lifting/lowering speed, load mass, and brake response speed) on the dynamic overload coefficient in the mechanism has been established. In particular, critical brake response speeds that cause maximum peak loads have been identified.

3. Justification of the need for adaptive control: The study confirmed that adaptive braking control is necessary to minimise dynamic loads and prevent premature wear, especially when working with loads close to the nominal lifting capacity. Traditional single-mode systems are not effective enough.

Practical significance of the results: The results obtained and the model developed can be used by engineers to: Optimise the settings of existing braking systems to reduce shock loads. Design new intelligent braking devices with the ability to automatically adjust the braking torque depending on the actual load weight and speed. Prospects for further research: Further work is advisable in the direction of developing algorithms for predictive brake control (Model Predictive Control, MPC) based on this model, as well as integrating vibration monitoring systems to assess the remaining service life of brake components.

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## PROSPECTS FOR OPTIMISING PARAMETERS WHEN INTRODUCING ARTIFICIAL INTELLIGENCE INTO THE MANAGEMENT AND OPERATION OF MOTOR GRADERS

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### Abstract

In the context of requirements for high-precision and energy-efficient reconstruction of Ukraine's infrastructure, the article discusses the principles and advantages of integrating artificial intelligence (AI) technologies into road construction machinery control systems, in particular motor graders. The main focus is on the use of machine learning (ML) and deep learning (DL) algorithms to optimise the operating parameters of hydraulic drives, predictive maintenance and achieve millimetre precision in road surface profiling.

**Keywords:** Motor grader, Artificial Intelligence, Machine Learning, Optimisation of operating parameters, Hydraulic drive, Predictive diagnostics, Precise levelling.

The traditional operation of motor graders, which are critical machines for profiling and levelling soil and road base materials, depends heavily on operator skill. This often leads to variations in the quality of the final profile, overuse of materials, and reduced overall energy efficiency of the machine.

Modern challenges, including the need for rapid and high-quality infrastructure reconstruction, require a transition to intelligent control systems. The goal of AI integration is to create an autonomous, self-adaptive grader (AI-Grader) capable of optimising its operating parameters (blade angles, travel speed, hydraulic parameters) based on data obtained in real time.

The effective AI-Grader is based on a closed-loop control system that includes:

- High-precision positioning systems: Use of multi-frequency GNSS receivers in combination with inertial measurement units (IMUs) to ensure blade positioning with an accuracy of 5–10 mm.

- Environment and status sensors: LiDAR and ultrasonic sensors for scanning the surface profile and hydraulic drive status sensors (pressure, temperature, flow).

- AI module (computing core): Based on high-performance microprocessors and specialised graphics accelerators for processing large amounts of data.

The architecture of the intelligent motor grader (AI-Grader) is divided into three interconnected levels that provide a closed control loop: perception, intelligence, and action.

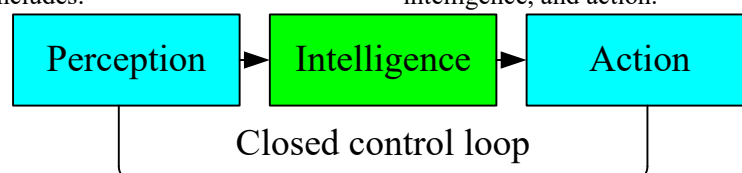


Fig. 1. Architecture of an intelligent motor grader

Perception (data input). This level is responsible for collecting highly accurate data about the external environment and the internal state of the machine.

Table 1

## Components of perception

| Components    | Function                                                                          |
|---------------|-----------------------------------------------------------------------------------|
| Positioning   | GNSS/RTK (GPS/GLONASS + Correction) and IMU (Inertial Unit)                       |
| Profile       | LiDAR/Laser scanners and ultrasonic sensors                                       |
| System Status | Pressure, temperature, and flow sensors in the hydraulic drive; vibration sensors |
| Control       | HMI (Human Machine Interface) for entering target parameters                      |

Intelligence (processing and decision-making).  
This is the central computing module where AI makes decisions.

Table 2

## Components of intellectual function

| Block               | Main task                                                                                               | Algorithms used                                      |
|---------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| Digital Twin        | Storage and updating of the target 3D model and comparison with the actual profile.                     | Spatial data processing.                             |
| Optimisation Module | Determination of optimal blade angles, travel speed and hydraulic flows to achieve the target accuracy. | Deep Reinforcement Learning (DRL)                    |
| Diagnostic Module   | Predicting wear on critical components (pumps, valves) and detecting anomalies.                         | Machine Learning (ML) and Neural Networks (CNN/LSTM) |
| Control Unit (ECU)  | Executing algorithms and generating control commands.                                                   | High-performance computing systems.                  |

Action (executive mechanisms). This level converts digital commands into precise physical movements.

Table 3

## Components of the action function

| Component           | AI-controlled function                                                                                       |
|---------------------|--------------------------------------------------------------------------------------------------------------|
| Hydraulic System    | High-precision proportional/servo valves and variable displacement pumps regulate the position of the blade. |
| Transmission/Engine | Speed and rpm control to maintain optimal load and energy efficiency.                                        |
| Working Equipment   | Automatic and precise control of all degrees of freedom of the blade (lift, tilt, angle of attack).          |

The closed control loop works as follows: perception (data collection) – intelligence (AI decision-making) – action (correction execution) – perception (result monitoring and feedback).

The key function of AI is to optimise the hydraulic system and working equipment parameters, namely adaptive blade control. This is the key function of the

intelligent motor grader (AI-Grader), which uses artificial intelligence (usually DRL) to achieve millimetre-accurate profiling. The diagram represents a closed-loop control system focused on continuous correction.

Adaptive blade control goes through three main stages: perception, decision-making, and action.

Table 4

## Stages and components of adaptive blade control

| № | Stage                     | Components                                                                                                             | Description                                                                                                                                                                                                                                                                                                                                      |
|---|---------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Perception (Monitoring)   | GNSS/RTK (positioning); IMU (tilt); LiDAR/Laser (actual profile); Hydraulic system sensors (pressure, soil resistance) | The system collects highly accurate data on the current position of the blade and the actual surface profile.                                                                                                                                                                                                                                    |
| 2 | Decision-making (AI core) | Digital Twin; AI module (DRL/MPC); ECU                                                                                 | 1. Comparison: AI compares the actual profile with the design profile. 2. Error Calculation: The levelling error and the necessary correction are determined. 3. Optimisation: The DRL algorithm calculates the optimal command for the hydraulic drive (angle change, depth) to minimise the error while taking energy efficiency into account. |
| 3 | Action (Execution)        | High-precision proportional/servo valves; Hydraulic cylinders                                                          | The electronic control unit (ECU) converts the AI command into a precise electrical signal that activates proportional valves for millimetre-precise blade movement.                                                                                                                                                                             |
| 4 | Feedback                  | GNSS/LiDAR data                                                                                                        | The changed position of the plough and its impact on the soil is again recorded by the Perception system (return to Step 1). This cycle is repeated continuously for adaptation.                                                                                                                                                                 |

Adaptive blade control operates according to a classic reinforcement learning cycle:

1. Sensors (Perception) transmit the state of the environment to the Agent.
2. The Agent (DRL) selects an Action (control command to the blade) based on the policy.
3. The Executive Mechanism (Hydraulic Drive) performs the Action.
4. The environment changes and gives a Reward (low profiling error is a high reward).

In this way, the DRL module learns to maximise the total reward over the entire operating time, which effectively means maximum accuracy and minimum energy loss.

Deep reinforcement learning (DRL) algorithms are used.

Deep Reinforcement Learning (DRL) algorithms are a cutting-edge approach in the field of artificial intelligence that combines the capabilities of deep neural networks with the principles of reinforcement learning (RL).

This allows an agent (e.g., an intelligent motor grader) to independently learn optimal behaviour in a complex, unpredictable environment based on experience and a reward/punishment system.

The DRL model learns to determine the optimal cutting and blade tilt angles, maximising material movement efficiency and minimising the load on the hydraulic system.

The reward function includes variables such as operating speed, accuracy of compliance with the design profile, and energy consumption.

#### Hydraulic Drive Optimisation:

AI continuously analyses pressure, temperature and flow data. Predictive models are used to regulate the working volume of pumps and the position of proportional valves, ensuring the required power with minimal heating and hydraulic losses.

Traditional maintenance of road construction machinery, including motor graders, is often based on either a failure-based or a scheduled (scheduled) approach. Both methods are inefficient: the first leads to costly emergency downtime, and the second to the replacement of components that are still in good working order.

AI takes motor grader diagnostics to a new level, preventing unexpected failures by:

Vibration and acoustic data analysis: ML algorithms (e.g., Support Vector Machines or Long Short-Term Memory Networks) are trained on vibration data from hydraulic pumps and gearboxes. They can identify abnormal spectra that indicate the early stages of bearing or seal wear long before an operator would detect it.

Working fluid quality control: AI analyses data from integrated oil contamination and temperature sensors, predicting when filters need to be replaced or fluid needs to be topped up, ensuring the longevity of the hydraulic drive.

AI-based predictive diagnostics (PdM) offers solutions using continuous monitoring and big data analysis to predict component failure times, allowing you to schedule service exactly when it is needed. This maximises part life and minimises downtime.

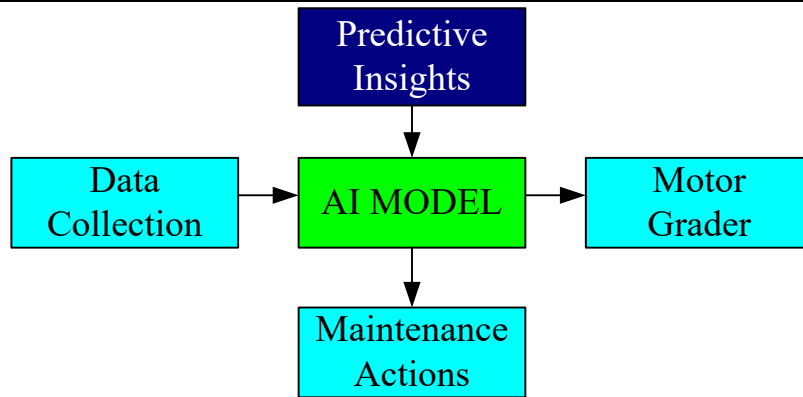


Fig. 2. Predictive diagnostics (pdm) of motor graders with artificial intelligence to improve reliability and operational efficiency

Система PdM інтегрується в загальну архітектуру AI-Grader і має три ключові рівні:

1. Level of Multisensor Data Collection:

Hydraulic system: sensors for pressure, temperature, flow rate, and wear particle content (contamination counters) in the working fluid.

Mechanical components (transmission, gearboxes): high-frequency accelerometers for vibration data collection.

Electrical systems: current and voltage sensors on actuators.

2. Analysis and processing level (Edge/Cloud Computing):

Feature extraction: vibration signals are converted to extract frequency features that indicate defects.

Normalisation and cleaning: noise filtering and data synchronisation.

3. AI level (Modelling):

State classification: use of machine learning (SVM, Random Forests) to classify the state of a component as "normal", "initial defect" or "critical wear".

Residual useful life (RUL) prediction: Application of recurrent neural networks (RNN), in particular LSTM (Long Short-Term Memory). These networks are effective for time series analysis and can predict when wear indicators will cross a critical threshold, determining the RUL of a machine element or node.

AI systems can detect defects such as:

Pump cavitation: detected through a specific vibration spectrum and efficiency drop.

Internal leaks: identified through abnormal relationships between pressure, flow, and valve position, even in the absence of external signs.

Oil contamination: analysis of particle counter data allows the prediction of potential valve or cylinder failure.

Maintenance schedules are optimised based on RUL predictions, with AI automatically adjusting maintenance schedules. For example, if analysis shows that hydraulic oil will be depleted earlier than expected due to increased load, PdM will initiate oil replacement ahead of schedule.

### Conclusions

The modern AI-Grader does not simply follow instructions; it learns. The system records how different types of soil react to certain manoeuvres and improves

its "experience" with every metre travelled. The introduction of AI into the control and operation of motor graders is an inevitable stage in the development of road construction machinery. AI-Grader is a self-adaptive system that provides:

- Increased profiling accuracy to the millimetre level.
- Significant reduction in fuel and operating material costs through process optimisation.
- Minimisation of downtime through predictive maintenance.

Motor graders are becoming computationally reliable systems. This not only increases safety and reduces operating costs, but also provides the necessary stability and high quality.

In the future, such machines will likely be integrated into a single construction site network (IoT for Construction), where they will be able to exchange data on soil conditions, optimising the operation of the entire fleet of equipment — from dump trucks to rollers.

An autograder with artificial intelligence is a symbol of a new era: an era where the quality of road construction is determined not by manual skill, but by the millimetre precision of intelligent algorithms.

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# MEDICAL SCIENCES

## NODULAR DESMOPLASTIC TRICHOBLASTOMA - CASE REPORT AND REVIEW OF DIAGNOSTIC CHALLENGES

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### Abstract

Trichoblastoma is a benign follicular neoplasm, exhibiting differentiation toward primitive hair germ structures. Desmoplastic variants are rare and may closely resemble invasive cutaneous carcinomas both clinically and histologically.

The paper reports a nodular desmoplastic variant of trichoblastoma, arising on the scalp, in a 65-year-old woman. Four closely grouped nodules were initially present and completely excised. A fifth lesion developed at the same site 3.5 years later; no further recurrence occurred during another 5 years of follow-up. Histopathologic examination showed well-circumscribed dermal nodules, composed of cords and nests of basaloid cells, radiating from hyalinized stromal foci. Small foci of keratinization and mucinous change were observed. Deeper areas revealed spindle-shaped epithelial cells within a dense desmoplastic stroma, with focal infiltration of the epineurium and arrector pili muscle.

The nodular desmoplastic variant of trichoblastoma represents a rare benign follicular neoplasm, that can mimic morpheiform basal cell carcinoma and other desmoplastic adnexal tumors. Recognition of this entity is essential to prevent overtreatment.

**Keywords:** desmoplastic trichoblastoma, hair follicle neoplasm

### Introduction

Trichoblastoma is a benign adnexal tumor, derived from primitive follicular germinative cells. Since its original description by Headington, several morphologic patterns have been identified, including nodular, retiform, and cribriform types. Desmoplastic trichoblastoma, though rare, is characterized by proliferation of basaloid cells within a dense, fibrotic stroma.

The histologic overlap between desmoplastic trichoblastoma and morpheiform basal cell carcinoma (BCC) poses a significant diagnostic challenge. Misinterpretation may lead to unnecessary extensive excision

or Mohs surgery. We report an unusual nodular desmoplastic variant of trichoblastoma, that further expands the histopathologic spectrum of this entity.

### Case report

A 65-year-old woman presented with four firm, dome-shaped nodules on the parietal scalp. The lesions had slowly enlarged over several months but were asymptomatic (fig. 1). There was no personal or family history of skin cancer or adnexal tumors.



*Fig. 1*

Complete surgical excision was performed. Histopathology at that time confirmed a benign follicular tumor, consistent with trichoblastoma. After 3.5 years, a new lesion appeared at the previous surgical site and was excised. The patient has remained recurrence-free for another 5 years, since that procedure.

Microscopic examination revealed multiple well-circumscribed dermal nodules, separate from the overlying epidermis. The superficial portions contained compact hyalinized stromal nodules, from which cords

and nests of basaloid cells radiated outward, resembling follicular germ differentiation (fig. 2).

Focal keratinization and mucinous (mucoid) change were noted within some epithelial islands. In deeper regions, the tumor cells acquired a spindle-shaped morphology and extended within a desmoplastic stroma. There was focal infiltration of the epineurium of small cutaneous nerves and involvement of arrector pili muscle fibers. No cytologic atypia, mitotic activity, or necrosis was presented.

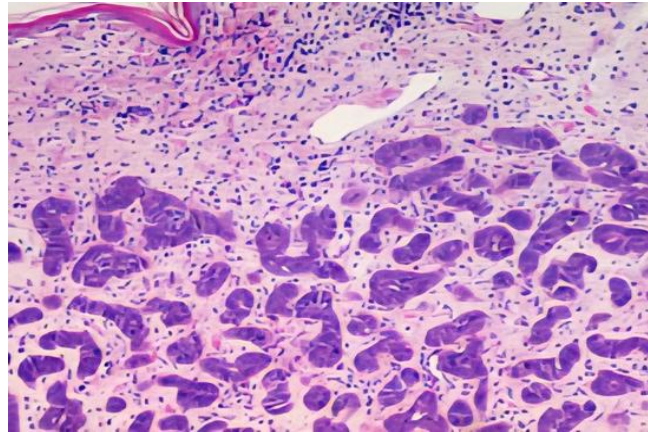


Fig.2

All these findings supported a diagnosis of nodular desmoplastic trichoblastoma.

The immunohistochemical examination was not performed, although it would have been necessary, as a potential supportive evidence.

The differential diagnosis includes:

- Morpheiform Basal Cell Carcinoma - that shares stromal sclerosis, but shows nuclear atypia, mitotic activity, and peripheral palisading;
- Desmoplastic Trichoepithelioma - usually smaller, presents with central keratin cysts and lacks hyalinized stromal nodules;
- Desmoplastic Trichilemmoma - that is connected to the epidermis with clear cell change and trichilemmal differentiation.

Recognition of benign follicular architecture and absence of malignancy are critical for correct diagnosis.

#### Discussion

Desmoplastic trichoblastoma is an uncommon adnexal neoplasm, that can clinically and histologically simulate infiltrative carcinoma. The desmoplastic stroma and spindle cell morphology, in deeper sections, may give an impression of invasion. However, the lesion typically remains confined to the dermis, with well-defined margins and bland cytologic features.

Recurrence after complete excision is rare but may occur, as in this case. Long-term follow-up is recommended, though metastasis has never been reported.

Understanding the histopathologic spectrum of trichoblastoma is vital to avoid overdiagnosis and unnecessary aggressive management. Immunohistochemistry and clinicopathologic correlation further aid in accurate classification.

#### Conclusion

The nodular desmoplastic variant of trichoblastoma is a benign adnexal tumor, that may closely resemble invasive carcinomas, due to its desmoplastic stroma and spindle cell morphology. Awareness of this variant and its distinguishing features is crucial to prevent misdiagnosis and overtreatment. Our case adds to the limited literature describing this rare entity.

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